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Species Endangerment Patterns in the United States

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INTRODUCTION

Concern for increased rarity among the Nation's animals and plants has grown rapidly in the past decade. The emergence of conservation biology as a discipline, and the institutionalization of the term biodiversity has been motivated, in large part, by the reported unprecedented rate of species extinction caused by human activity (Lewin 1986; Wilson 1988, 1992). Although biodiversity is an attribute of ecological systems that cannot be simply quantified, there is little disagreement that diversity diminishes as species become extinct. Consequently, much of the interest in rare species stems from the assumption that those species are the most prone to extinction, and that by understanding the processes that have contributed to their rarity, further loss of diversity may be slowed or reduced (McIntyre 1992).

The problem of species endangerment has led scientists and resource managers to use rare biota as the basis for ranking species according to the urgency of conservation efforts. The species-by-species strategy is the basis of implementation of the Endangered Species Act of 1973 (ESA; P.L. 93-205), a law widely regarded as the strongest ever devised for species preservation by any nation (Doremus 1991, Greenwalt 1991, O'Connell 1992). The predominance of single-species (i.e., autecological) strategies for species preservation can be traced, in part, to the history of wildlife management and conservation in this Country.

Endangered Species Legislation

Protecting species from extinction has long been a central principle of the relationship between humankind and the natural environment (Marsh 1864, Leopold 1953); perhaps the strongest affirmation of this is embedded within the ESA. Although legislation that specifically addresses the issue of species extinction is relatively recent, current federal mandates governing threatened and endangered species reflect an evolution over decades of increasing federal authority in the regulation of wildlife resources, and society's increased recognition of the values of maintaining biological diversity (Kellert 1986, O'Connell 1992).

Historically, wildlife resources were under the sole authority of state governments—a doctrine derived from English common law. Regulations during the late 1800s were specific to individual game species (Gilbert and Dodds 1987:7), with the main management objective of perpetuating the harvest. Restrictions enacted by the states, however, lacked adequate enforcement, and failed to stem declining wildlife populations (Lund 1980, Ernst 1991). Early federal legislation, such as the 1894 Yellowstone Park Protection Act and the Lacey Act of 1900, was intended primarily to arrest the decline of traditional game species. This began stricter federal regulation over the taking of wildlife. These acts were followed by a continued broadening of federal authority in restricting game harvests, and the establishment of a regular funding base to support habitat acquisition.

The Federal Government effectively assumed custody over migratory bird species within U.S. borders, and recognized the importance of international cooperation in their protection through the 1918 Migratory Bird Treaty Act. Authority and funding for habitat acquisition was provided primarily under the 1934 Migratory Bird Hunting Act, the 1937 Pittman-Robertson Act, and the Fish and Wildlife Act of 1956 (Lund 1980). Although these early mandates, and many other subsequent acts, promoted the protection of jeopardized wildlife resources, habitats and individual species were given federal protection in an ad hoc fashion (Lund 1980, Doremus 1991, Pimentel et al. 1992). A systematic and comprehensive authority for protecting endangered biota still was lacking.

Predecessor to the U.S. Fish and Wildlife Service (USFWS), the Department of Interior's Bureau of Sport Fisheries and Wildlife, convened a committee of nine biologists in 1964 to compile a list of wild species whose existence was thought to be in jeop-

ardy (Drabelle 1985). This list, dubbed the "redbook," was comprised of 63 vertebrate species informally identified by the committee to be in danger of extinction. The first federal law aimed at governing such species was passed in 1966; but the Endangered Species Preservation Act and the subsequent Endangered Species Conservation Act of 1969 were too weak and open to interpretation to be considered significant protection for wildlife (Rohlf 1989). Despite the criticisms, these acts were regarded as great conservation achievements (Doremus 1991, Kohm 1991), because they apparently transcended the species-specific legislation that had characterized previous conservation efforts. Admittedly, the general problem of species preservation now could be addressed under a single mandate. However, protection was still afforded to each individual species through a process of listing proposals and identification of autecological needs.

Growing public interest in environmental issues played a critical role in the virtually unopposed passage and signing of the ESA, in 1973. This Act codified broad-ranging protection for all species, plant and animal, encompassing species in immediate danger of extinction, as well as species that may be threatened with extinction in the foreseeable future. Among other notable provisions, the Act made the "taking" of endangered species anywhere within the United States a federal offense; required all federal agencies to use their existing authorities to conserve listed species; prohibited federal agencies from taking actions that may jeopardize a species' existence (Section 7); provided a formal structure for the listing and management of endangered species; and provided a means for citizens to bring suit against any federal agency for failure to meet its obligations under the Act. Language in the Act even appeared to address the looming problems associated with the species-by-species approach to species conservation.

As reviewed by Lund (1980:96), one objective of ESA implies conservation of ecosystems deemed critical to the health of endangered species. In practice, however, the potential for protecting species collectively through preservation of these critical ecosystems has never been fully realized. Implementation of the ESA, while an improvement on the earlier acts, never proved to be the radical departure in approach implied by its reference to ecosystem protection (Doremus 1991:303). Instead, the species-by-species orientation remained, and has become a focus for criticism of U.S. species preservation policy (Hutto et al. 1987).

Criticisms and Alternatives

After passage of the ESA, the USFWS was inundated with species petitioned for listing. Petitions for approximately 24,000 species were received less than 2 years after the Act was passed (Reffalt 1988). To handle the high rate of species petitioning, the USFWS had to establish criteria by which species in danger of extinction could be ranked—a priority system often described as "triage" (Norton 1987:258). In addition to severity of the extinction threat and probability of recovery, this priority system also used criteria related to public preferences, which have a documented bias toward higher orders of animals (Rohlf 1991, Gibbons 1992, Pimentel et al. 1992).

Besides the criticisms associated with the logistics of handling the number of species petitioned for listing, other weaknesses within the Act were noted (Doremus 1991, Rohlf 1991). Many interests, particularly within business and industry, objected to the lack of economic considerations in listing decisions, while others criticized the Act's apparent disregard of a predominant cause of species endangerment — habitat loss and degradation. Amendments to the ESA, passed in 1978, attempted to address the latter two issues by mandating designation of critical habitat concurrent with species listing, and, to ease the added cost burden implied by such a measure, directed the Secretary of the Interior to consider economic impacts in determining critical habitat (ESA Amendments of 1978, P.L. 95-632, 92 Stat. 3751).

The increasing number of species petitioned for listing and the critical habitat requirement together nearly slowed the listing process to a halt in 1982, making further amendments necessary. To speed the listing process, the Secretary of the Interior was directed to issue a preliminary finding within 90 days of receiving a petition for listing, as to whether sufficient information was available to warrant the petitioned action (ESA Amendments of 1982, P.L. 97-304, 96 Stat. 1411). An allowance also was made to postpone critical habitat designation until an unspecified later date, in the hopes of easing the overall backlog in listing. Finally, in response to continuing difficulties in managing the number of species petitioned, Congress extended ESA protection in the

1988 Amendments (P.L. 100-478, 102 Stat. 2306) to species awaiting official consideration, directing the Secretary to monitor the status of candidate species and to issue emergency regulations as necessary for their protection.

With an increasing petition rate since 1987 (U.S. General Accounting Office 1992), and a growing backlog of candidate species, fundamental procedural changes may be necessary to address the species endangerment problem. Critics generally blame the current listing logjam on two factors: foremost is the lack of adequate resources to fulfill the Act's requirements. A second factor may best be described as flawed implemenation leading to erroneous assumptions and improper models of the biology and causes of rarity and extinction (Rohlf 1991, O'Connell 1992, Ralls et al. 1992). Not only is the autecological treatment of current endangered species policy unwieldy and slow; it ignores the dynamics of ecological systems as a whole; and its interpretation and use of complex and occasionally conflicting taxonomic definitions has been characterized as indecipherable (Fergus 1991, O'Brian and Mayr 1991).

Several modifications to the ESA and new approaches to addressing species endangerment have been suggested, including increased investments in cryogenics and gene banking (Soulé et al. 1986), cost-effectiveness modeling (Hyman and Wernstedt 1991), reconsideration of the priority system governing resource allocations (U.S. General Accounting Office 1988), population viability analysis (Shaffer 1981, 1990), decision analysis (Maguire 1986), and increases in authorized funds and personnel (O'Connell 1992). These improvements, however, remain consistent with the current pattern of autecological conservation and protection. Far more significant are proposals to reorient U.S. endangered species policy completely; emphasizing evolutionary and ecological significance of a species in making policy decisions, managing representative ecosystems as complete units for preserving ecological diversity, and analyzing the causes of and trends in species endangerment (Hutto et al. 1987, Scott et al. 1988, Doremus 1991, and Rohlf 1991). The logistic and financial constraints associated with addressing the ecological requirements of thousands of endangered, threatened, and candidate species suggests that biological organization above the species level may be a more efficient and comprehensive approach to species conservation (Noss 1991).

Alternatives, alluded to previously, have been variously termed the habitat (Norton 1987), the ecosystem (Salwasser 1991), the coarse-filter (Hunter et al. 1988), the community (McIntyre 1992), or the biological template approach (Knopf 1992). The fundamental feature common to these approaches is to focus preservation efforts on ecologically important habitats or ecosystems. By focusing on habitat protection, rather than individual species recovery, species would be protected before they reach critically low population sizes; species assemblages and their roles in maintaining vital ecosystem processes would be preserved intact; and many of the human-values for species diversity would be addressed simultaneously (Norton 1987, Leitzell 1986).

The apparent simplicity of the ecosystem approach, and claims that the general shape of such a policy strategy is clear (Norton 1987:268), mask conceptual difficulties that would hinder its implementation. These difficulties can be traced to two concerns. First, the habitat approach is based on the assumption that vegetation types or associations (often interpreted as surrogate entities for communities or ecosystems) can be delineated objectively and clearly. However, classification systems identifying natural communities tend to be ad hoc (Scott et al. 1991); and there is no generally accepted taxonomy of habitats, communities, or ecosystems (Orians 1993). The lack of a universally accepted classification system is further compounded by the fact that, even within a geographic region, numerous competing classification systems can exist (McLaughlin 1989).

A second concern with the habitat approach is related to the unstated assumption that species assemblages within habitats, communities, and ecosystems are stable and predictable. If they are not, — and there is accumulating evidence that they are not (Pickett et al. 1992) — then it becomes difficult to devise a classification system upon which to base a preservation strategy (Hunter 1991). Consequently, conservation recommendations to set aside areas will not necessarily preserve ecosystem function (Emlen et al. 1992), because some ecological processes transcend the boundaries of human-defined classification systems (e.g., wide-ranging animals, migration, wild fire).

Although many agencies and private institutions have established criteria for evaluating the conservation value of lands being considered for protection, the conceptual difficulties outlined here raise impor-

tant concerns over whether the habitat approach is feasible and whether it is a realistic alternative to the current species-by-species conservation strategy.

An alternative that has received less discussion involves focusing on broad patterns among species currently listed as threatened or endangered. Patterns associated with the distribution of endangered biota are prerequisite to defining characteristics of species or environments that are predisposed or susceptible to endangerment (Slobodkin 1986, Williams et al. 1989), and to the identification of species and regions subjected to the highest level of endangerment stress (Noss 1991, Raven and Wilson 1992). This would allow preservation efforts to focus on regions where the efficiencies associated with multispecies benefits are more likely to be achieved.

Objectives

Examination of broad patterns associated with listed species has been hindered by the lack of basic distributional data on endangered species (Doremus 1991:310), at least in a consolidated format. This, in part, is because many of the species listed are obscure and lack study of their basic life history. However, distributional information and environmental associations of listed species have been accumulating over the past decade, thereby relaxing the data constraints associated with describing broad endangerment patterns.

Table 1.—Taxonomic comparison of the number of threatened and endangered species and average annual rate of listing from July 1976-August 1992 (USDI, Fish and Wildlife Service 1976b, 1992).

Taxon	July 1, 1976	August 31, 1992	Rate (Species/year)
Mammals	36 (20%)	65 (9%)	1.8
Birds	66 (37%)	85 (12%)	1.2
Reptiles	8 (4%)	34 (5%)	1.6
Amphibians	4 (2%)	11 (2%)	0.4
Fishes	34 (19%)	91 (13%)	3.5
Snails	-	13 (2%)	0.8
Clams	22 (12%)	42 (6%)	1.2
Crustaceans	-	10 (1%)	0.6
Insects	8 (4%)	23 (3%)	0.9
Arachnids	-	3 (<1%)	0.2
Plants	-	351 (48%)	21.7
Total	178	728	34.0

Considering these data, the objectives of this report are to review the basic temporal trends in species listed as threatened and endangered; to identify broad synecological patterns from the distribution of listed species (i.e., identify regions of high species endangerment); and to describe the taxonomic composition, climatic attributes, land-type associations, and factors that have contributed to species endangerment within regions where extinction risk is concentrated. Future geographic patterns of species endangerment also are examined, based on the distribution of species being considered for future listing.

TEMPORAL TRENDS IN LISTING THREATENED AND ENDANGERED SPECIES

In July 1976, the USFWS started publishing technical bulletins to help exchange information among agencies and organizations cooperating and interested in the Endangered Species Program (USDI, Fish and Wildlife Service 1976a). These technical bulletins chronicle the changes in the rates of listing species, and shifts in the relative emphasis given to major taxa.

Over the past 16 years, an average of 34 new species a year were afforded protection under the ESA. Whereas vertebrate species dominated the list during the first three years of the Act, plant species (48%) and invertebrates (13%) now comprise a much greater proportion of the listed biota (table 1). Although these data indicated broad patterns in listing trends of threatened and endangered species, averages over 16 years mask the dynamic nature of species listing.

Phases in Species Listing Since 1976

The number of threatened and endangered species annually listed has varied greatly, ranging from a net addition of 4 species during both the 1981 and 1983 calendar years, to more than 75 species in 1991. Cumulative plots of the number of threatened and endangered species indicated three phases in the listing of species (fig. 1).

Phase 1 (July 1976-October 1978) was characterized by a gradual increasing rate of species listings for both plants and animals. Overall, 58 species were added to the list during this time, for an average rate

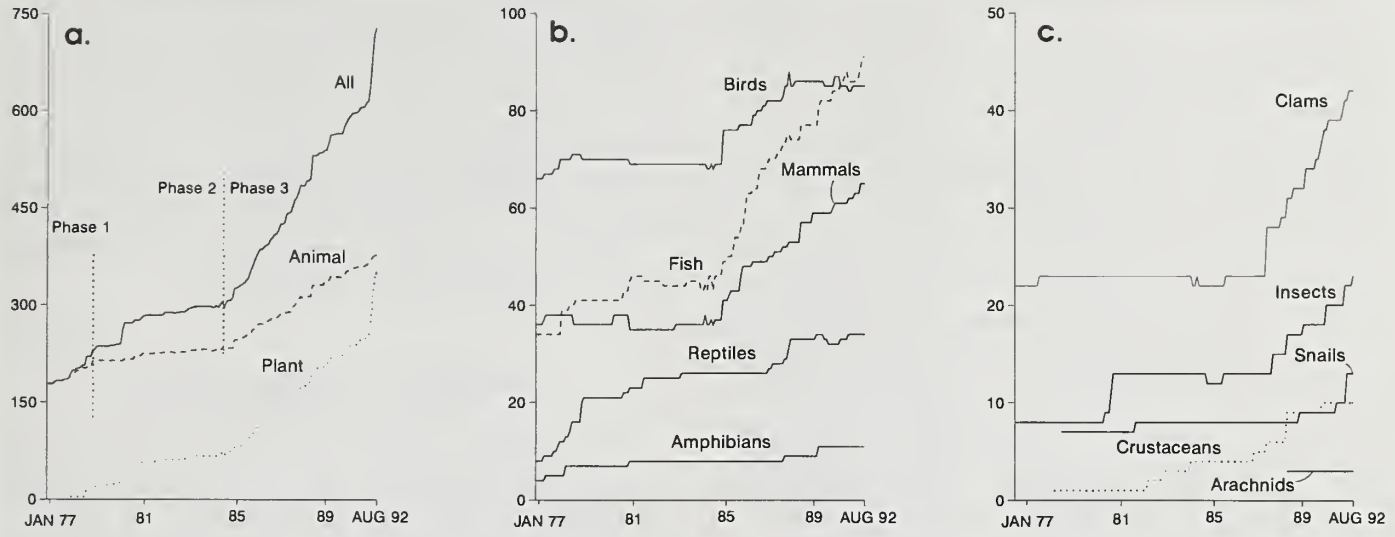


Figure 1.—Cumulative plot of species listed as threatened and endangered from June 1976-August 1992 for all taxa (a), vertebrates (b), and invertebrates (c).

of 2.1 species a month. The greatest net increase among animals was associated with reptiles, fish, and snails (fig. 1). Other than snails, invertebrates received relatively little attention, with insects being the only taxonomic group that did not observe a new listing during this period.

The first plant listings occurred during Phase 1 (August 1977) and the observed increase in the overall rate of species listing resulted largely from the addition of plants. Plants were not afforded protection under endangered species legislation until the 1973 ESA. Two years after the passage of the 1973 Act, 3,187 plant species were submitted for possible listing as endangered or threatened status. Review of these proposed plants led to the designation of approximately 1,750 U.S. plants as candidates for endangered status by June 1976 (USDI, Fish and Wildlife Service 1976c), establishing a substantial backlog of plant species that required formal evaluation.

The 64-month Phase 2 (November 1978-February 1984) was distinguished by general inactivity. A total of 60 species was added to the list, for an average monthly rate of 1.1 species. This rate is inflated by a flush of listings (32 species) associated primarily with plants (30 species, 22 of which are members of the cactus family) that occurred over a relatively short time (October-November 1979) (USDI, Fish and Wildlife Service 1979). Apart from this brief period of activity, Phase 2 is conspicuous in the lack of new species that were afforded protection under the ESA. This inactivity appears related, in part, to 1978 amendments that substantially altered the original listing process, by requiring that each species listing be accompanied by the designation of critical habitat, and by numerous new requirements for hearings and local notice (Kohm 1991). Logistically, these changes were burdensome and difficult to implement, leading to the apparent inactivity associated with evaluating the merits of species proposed for ESA protection.

For the past 8 years (Phase 3), the rate of species listing has increased greatly—an average of 4.2 species a month, for a total addition of 432 species. Plant species (2.8 species a month) were listed at nearly twice the rate of animal species (1.4 species a month), as were vertebrates (1 species a month) compared to invertebrates (0.4 species a month). Among the animal taxa, fish gained the most species (48), followed by mammals (29), clams (19), and birds (17). Again, the notable increase in the rate of listing is a function of amendments to the Act passed in 1982 and 1988, that were directed at expediting the listing process (Kohm 1991).

Two particularly active listing periods within Phase 3 occurred from May to November 1988, and from July 1991 to May 1992. Both periods were dominated by additions of plants. The earlier period was associated with wetland and aquatic plants (USDI, Fish and Wildlife Service 1988a); the latter period was associated with the listing of Hawaiian plants (USDI, Fish and Wildlife Service 1991).

Comparison of the pattern among taxa indicate listing biases over time (fig. 1). Although the rate of plant species listing increased recently relative to animals, the rate of listing does not appear to be commensurate with the endangerment problem facing plant species. In an independent evaluation of plant rarity in the United States, the Center for Plant Conservation (unpublished CPC Endangerment Survey; December 9, 1988) estimated that 680 plant species were critically endangered. Approximately 253 of these plant species were estimated to become extinct within 5 years; 427 were estimated to vanish in 10 years; and approximately 8% were already thought to be extinct. As of November 30, 1988, only 201 plant species were formally protected under the ESA (USDI, Fish and Wildlife Service 1988b).

Fish taxa, like plants, also have shown a greater rate of listing than other taxa, particularly during the mid-1980s. However, an evaluation of the status of North American fishes by Williams and Miller (1990) indicated that nearly 50% of the species qualifying for listing are not being afforded protection under the ESA. Of the known number of North American freshwater fishes (1,033 species), 292 (28%) are included in the International Union for Conservation of Nature and Natural Resources (IUCN) as either endangered (74 species), vulnerable (85 species), rare (101 species), indeterminate (5 species), or are now believed to be extinct (27 species) (Williams and Miller 1990:80). The endangered and threatened categories of the ESA approximate the endangered and vulnerable categories of the IUCN. Of the 102 U.S. species classified as endangered or vulnerable, only 54 were listed pursuant to the ESA (Williams and Miller 1990:82).

The incongruence between species thought to qualify for ESA protection and those species that are formally listed is not a trivial problem. This is particularly apparent when evaluating the status of species that have been afforded protection. As of October 1, 1990, there were 581 species listed as threatened or endangered—only 10% of those species were considered to have increasing populations, 38% were considered declining, 31% were estimated to have stable populations, 19% had unknown status, and 2% were believed to be extinct (USDI, Fish and Wildlife Service 1990b:15). Species with declining populations or unknown status were most prominent among plants (57% of plant species listed), invertebrates (81%), fish (51%), and amphibians and reptiles (79%), suggesting that less prominent species may be at greater risk of extinction. Furthermore, Wilcove et al. (1993) found that the median size of plant populations at the time of listing was fewer than 120 individuals. If this is a general pattern, then species qualifying for protection but not yet formally listed, which are dominated by the more obscure taxa, may have a disproportionate number of species that are in critical need of protection.

Trends in Candidate Listings

The USFWS periodically has compiled lists of species that merit evaluation for potential listing as threatened or endangered, as defined by the 1973 ESA (Reffalt 1988). The "Candidate List" appears to have been used first in a 1980 notice (USDI, Fish and Wildlife Service 1980) reviewing the vulnerability of about 3,000 U.S. plants to extinction. In that notice of review, three categories of conservation status were defined. Category 1 included those species for which the USFWS has sufficient biological evidence to support their official listing as threatened or endangered. Category 2 species have evidence to indicate that listing may be appropriate, but conclusive biological evidence is lacking. Category 1 and 2 constitute those species considered active candidates for listing. Category 3 species are no longer being considered for listing as threatened or endangered for one of three reasons: (1) the USFWS has evidence that the species is now extinct (Subcategory 3A), (2) the species is not a taxon meeting the ESA's definition of "species" qualifying for protection, (3) the species is considered to be more widespread or abundant than previously thought (USDI, Fish and Wildlife Service 1981).

During the 1980s, the Fish and Wildlife Service periodically published notices concerning candidate species, at approximately 5-year intervals. Monitoring candidate species now is formally required under the 1988 amendments to the ESA (Doremus 1991). A compilation of notices published during the 1980s permitted an evaluation of the trends in candidate species by taxonomic category.

Among vertebrate taxa, the number of candidate species remained relatively stable during the 1980s (table 2). Fish species dominate the Category 1 listing and also are characterized by the largest number of candidates that are believed to be extinct. Although

Table 2.—Trends in the number of candidate and Subcategory 3A (now believed extinct) species from 1980-1990 (USDI, Fish and Wildlife Service 1980, 1982, 1984, 1985a, 1985b, 1989, 1990a).

Taxon	Category 1			Category 2			Subcategory 3A[1]		
	1980-82	1984-85	1989-90	1980-82	1984-85	1989-90	1980-82	1984-85	1989-90
Mammals	9	5	7	59	224	202	1	5	9
Birds	16	8	5	55	44	54	1	2	7
Fish	31	17	15	105	111	118	5	8	13
Reptiles	4	4	1	43	49	54	3	3	3
Amphibians	2	1	4	43	52	50	2	2	2
Vertebrates	62	35	32	305	480	478	12	20	34
Clams	-	6	2	-	41	59	-	12	11
Snails	-	22	27	-	110	143	-	1	2
Insects	-	8	9	-	459	584	-	66	68
Arachnids	-	0	1	-	8	27	-	0	0
Crustaceans	-	3	2	-	69	91	-	1	1
Other[2]	-	0	0	-	9	14	-	2	2
Invertebrates	-	39	41	-	696	918	-	82	84
Animals	62	74	73	305	1176	1396	12	102	118
Plants	1822	1075	526	1176	1651	1572	51	60	94

[1]*Number of Subcategory 3A species reflect cumulative totals.*

[2]*Other includes sponges, hydroids, flatworms, earthworms, and millipedes.*

many Category 2 species are fish, this group of candidates is dominated by mammalian species, which comprised about 45% of the total Category 2 vertebrates in the late 1980s.

Unlike the vertebrates, the number of invertebrate candidate species was more dynamic during the 1980s. There was a 30% increase in the number of candidate invertebrate species from the mid- to late 1980s. Because less is known about the distribution, abundance, and life history of invertebrate species (Opler 1987), most candidates are in Category 2. Insects dominate the candidate list of invertebrates, comprising more than 60% of the species. Insects also dominate the number of candidates now believed to be extinct.

These comparisons among taxa have not been adjusted for differences in the total number of species in each taxon. Because insects are speciose, one would expect more extinctions among insects because of chance alone. Although many more insect species are now believed extinct than other taxa, Hafernik (1992:174) considers the true number of insect extinctions to be much higher, perhaps an order of magnitude higher.

The number of Category 1 plants has varied more than among animal taxa. Part of this is caused by the relatively rapid rate that plants have been added to the threatened and endangered species list in recent years, which resulted in removing species from candidate status. The estimated number of candidate plant species that are believed extinct may be biased low—8% of candidate animal species are believed extinct, compared to only 4% of candidate plant species.

ENVIRONMENTAL ASSOCIATIONS AND SPATIAL DISTRIBUTION OF LISTED SPECIES

Data Sources

The Endangered Species Program of the U.S. Fish and Wildlife Service began the development of an endangered species information system in 1981, in an effort to enhance information transfer among federal and state agencies, and other users interested in threatened and endangered species (Knapp, pers. comm., U.S. Fish and Wildlife Service 1987). Information on 436 species was acquired from the USFWS, from their information system, in April 1990. Since then, information on an additional 231 species have been added to the database.[3]

Various sources were used to compile distributional, biological, and administrative information on threatened and endangered species, including Fed-

[3]*Database was compiled by BioData, 13950 West 20th Ave., Golden, CO 80401, under contract with the USDA Forest Service*

eral Registers, USFWS Endangered Species Technical Bulletins, species recovery plans, other federal agency reports, and consultation with USFWS Regional Biologists and State National Heritage Programs. For each of the 667 species in the database, we extracted information on taxonomy, known county occurrence, known occurrence on public lands (by federal and state agency), land-type associations based on the broad land cover classification of Anderson et al. (1976) and the forest and rangeland ecosystem classification of Garrison et al. (1977), and general factors (e.g. habitat loss, human overuse) and specific reasons (e.g., forest clearing, grazing, collecting) contributing to species endangerment. The 68 additional species that were on the official list (as of August 31, 1992 [USDI, Fish and Wildlife Service 1992]), but were not included in the database, are predominately plant species for which there was limited information.

Land-Type Associations Among Listed Species

Land-type associations among listed species were based on the land cover classification of Anderson et al. (1976). In developing this classification system, Anderson et al. (1976) tried to use land cover definitions that were consistent with those used by other federal agencies. We used five broad natural land cover categories to describe land-type associations among threatened and endangered species, including forest, range, barren, wetland, and water. Within each broad land cover type, the number of subcategories ranged from two for wetland habitats to seven for barren land.

More threatened and endangered species were associated with forest ecosystems than the other general land cover categories (table 3). Animals comprised most of the species associated with forest environments — a pattern observed consistently among all land types, except barren land, where plant species dominated. Invertebrate species were associated with aquatic environments, particularly water systems embedded in forested landscapes.

Within forest habitats, evergreen types supported more threatened and endangered species than mixed or deciduous types (table 3). Among taxa, most forest-associated mammalian, avian, reptilian, insect, and plant species were found in evergreen types; these taxa comprised more than 65% of all listed species that were associated with forest habitats. Mollusks and crustaceans were the only taxa where

Table 3.—Land-type associations among 667 threatened and endangered species. Species can occur in more than one land type category.

Land Type	All T&E	Plant	Animal	Mammal	Bird	Reptile	Amphibian	Fish	Snail	Clam	Crustacean	Insect
Forest	312	109	203	29	48	16	6	54	10	25	9	6
Deciduous	128	39	89	11	7	7	2	28	8	19	6	1
Evergreen	178	60	118	21	41	10	2	28	2	8	1	5
Mixed	110	34	76	15	16	11	4	19	2	7	2	
Rangeland	271	125	146	22	31	12	6	60	3	1	2	9
Herbaceous	101	41	60	8	15	5	2	25	1			4
Shrub/Brush	170	72	98	14	12	11	4	47	2	1	2	5
Mixed	85	25	60	12	19	6	2	19				2
Barren	176	96	80	16	25	16	2	9	4	1		7
Beaches	35	3	32	7	13	10						2
Dry Salt Flats	17	8	9	1	5	1		2				
Exposed Rock	81	58	23	4	11	1	1	3	3			
Mines/Quarries/Pits	29	13	16	2	3	2		3	1	1		4
Sand (not beach)	43	22	21	2	10	4	1	1				3
Mixed	17	7	10	2	6			1				1
Transition	26	7	19	3	9	2		2	1			2
Water	244	24	220	16	33	14	5	92	5	42	10	3
Bay/Estuary	38	2	36	6	17	7		4		1	1	
Lakes	49	3	46	3	18	4	2	17			2	
Reservoirs	61	4	57	4	15	5	1	31				1
Stream/Canal	217	22	195	13	23	10	4	88	5	41	8	3
Wetland	155	47	108	23	40	9	5	23	2	1		5
Forested	71	16	55	15	20	7	2	8	1			2
Nonforested	121	37	84	18	30	9	3	18	2	1		3

the majority of forest species were associated with deciduous types, although these taxa only comprise a small proportion (14%) of forest-associated species.

Shrub and brush rangelands supported nearly 63% of those threatened and endangered species that were associated with rangeland habitats (table 3). Predominant taxa associated with shrub and brush lands were plants and fish, which comprised 119 of the 170 species associated with this cover type. Eleven out of the 12 reptile species associated with rangeland habitats were associated with shrub and brush lands.

More than 25% of the 667 species in this data set were associated with barren land habitats. Half of those species were plants; and most of these plant species were associated with natural exposed rock habitats. Among animal taxa, much of the barren land associations with threatened and endangered species were concentrated in mammals, birds, and reptiles, particularly in affiliation with beach or dune environments.

Water associations are dominated by fish and mollusks, but not to the exclusion of other taxa. Nearly one-third of the listed mammals and birds are found in open water environments (table 3). Many more threatened and endangered species were associated with lotic compared to lentic systems; this pattern is consistent among all taxa. No more than 25% of the listed species affiliated with aquatic environments use lakes, reservoirs, or bays and estuaries.

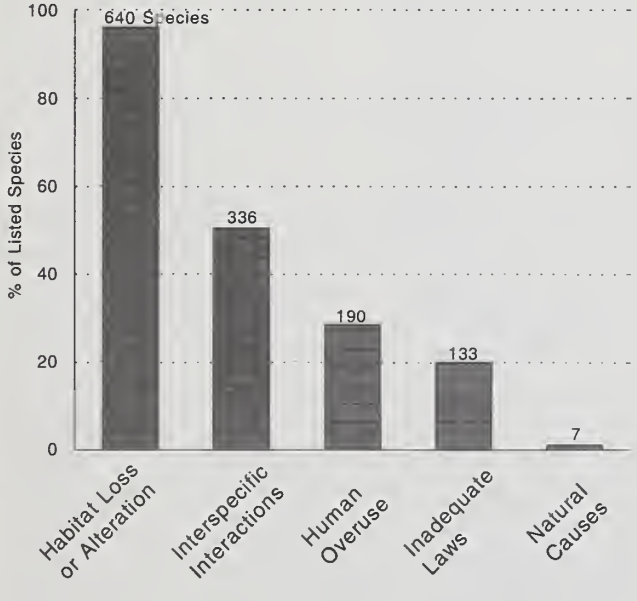


Figure 2.—Percent and number of threatened and endangered species whose status is a function of general reason categories.

Although wetland habitats supported fewer threatened and endangered species than the other terrestrial or aquatic environments, this relatively rare habitat type supported a disproportionately high number of listed species. Wetlands comprise only 5% of the land base in the conterminous U.S. (Tiner 1984); yet, nearly 30% of listed animal species and approximately 15% of listed plant species were associated with wetlands.

Greater detail in land-type affinity was possible with forest and rangeland ecosystems based on the classification system of Garrison et al. (1977). Forest types that had at least one successional stage associated with at least 10% of the 312 forest-associated listed species included longleaf-slash pine, oak-hickory, oak-pine, loblolly-shortleaf, oak-gum-cypress, and ponderosa pine forests (table 4). No western forest type, other than ponderosa pine, had a successional stage that was associated with at least 10% of forest species. Associations among successional stages indicate that slightly more species were associated with mature and old-growth forests than earlier successional stages.

Associations of listed species among range ecosystems indicate that arid shrubland systems provide the life requisites for many of the species, supporting 12-30% of the threatened and endangered species inhabiting rangelands (table 4). Rangeland systems dominated by herbaceous vegetation that also supported at least 10% of rangeland-associated threatened and endangered species included desert grassland, wet grassland, and annual grassland.

Factors Contributing to Species Endangerment

General factors believed to adversely affect threatened and endangered species include habitat loss or alteration, human overuse, interspecific interactions (including disease, predation, and competition), other natural causes, and inadequate laws concerning resource management. Habitat loss associated with land use intensifications was the single most important factor in species endangerment. More than 95% of the 667 species in the database had habitat loss or alteration indicated as a factor explaining the current status of the species (fig. 2). Interspecific interactions, particularly those associated with introduced species, have adversely affected more than 50% of the species.

Table 4.—Pattern of association between threatened and endangered species and forest and rangeland ecosystem types. Forest type successional stages are defined as: SS-shrub-seedling stand (trees ≤ 1" in diameter); YS—young stand (trees 1"-9" in diameter); MS—mature stand (trees > 9" in diameter); OG—old growth (stand with evidence of rotting, or dying trees caused by old age).

Forest/Range Type[1]		Number of Species (%)[2]	Plant	Animal	Mammal	Bird	Reptile	Amphibian	Fish	Snail	Clam	Crustacean	Insect
Forest Types													
Longleaf-Slash	SS	37 (12)	19	18	2	3	5		3	1	4		
	YS	38 (12)	18	20	4	3	5		3	1	4		
	MS	37 (12)	15	22	4	4	5		3	1	5		
	OG	28 (9)	9	19	2	4	5		3	1	4		
Oak-Hickory	SS	55 (17)	10	45	3		1		17		20	3	1
	YS	59 (19)	12	47	3		1	1	17	1	20	3	1
	MS	74 (24)	17	57	6	1	1	1	19	3	20	5	1
	OG	63 (20)	12	51	6	1		1	17	2	20	3	1
Oak-Pine	SS	54 (17)	16	38	2	2	4		11	1	17	1	
	YS	57 (18)	16	41	2	2	6	1	11	1	17	1	
	MS	63 (20)	17	46	6	2	5	1	11	1	18	2	
	OG	47 (15)	6	41	5	1	5	1	10	1	17	1	
Loblolly-Shortleaf	SS	31 (10)	15	16	1		2	1	10	1	1		
	YS	32 (10)	15	17	1		2	2	10	1	1		
	MS	32 (10)	12	20	2	2	2	2	10	1	1		
	OG	24 (8)	5	19	2	2	1	2	10	1	1		
Oak-Gum-Cypress	SS	27 (9)	2	25	3	4	3		3		11	1	
	YS	29 (9)	2	27	3	5	3		3	1	11	1	
	MS	33 (11)	3	30	5	6	3		3	1	11	1	
	OG	33 (11)	3	30	5	6	3		3	1	11	1	
Ponderosa Pine	SS	18 (6)	2	16	1	2			12			1	
	YS	20 (6)	3	17	1	2			12			1	1
	MS	31 (10)	7	24	1	3			17			1	2
	OG	27 (9)	5	22	2	3			16			1	
Range Types													
Chaparral-Mountain Shrub		32 (12)	14	18	3	5	3	1	2				4
Desert Grasslands		30 (11)	15	15		3			12				
Desert Shrub		82 (30)	31	51	5	7	3	1	34				1
Pinyon-Juniper		49 (18)	25	24	2	2	1		18			1	
Sage Brush		42 (15)	11	31	3	3		1	23			1	
Wet Grasslands		38 (14)	12	26	7	12	1	2	1	1			2
Annual Grasslands		29 (11)	14	15	5	2	2		1				5

[1]*Only those forest and rangeland systems that supported ≥10% of the species associated with these ecosystems are listed.*

[2]*Percentage of forest- or range-associated threatened or endangered species.*

The third most frequent factor contributing to species endangerment was human overuse associated with the harvest, collection, or commercial trade of species. Relative to other taxa, human overuse of fish species was less frequently cited—15% of the fish species listed as threatened or endangered. The infrequent implication of human overuse as a factor contributing to endangerment of fish also has been noted in other studies of rare North American fish fauna (Williams et al. 1989). Human overuse was indicated a disproportionately high number of times for mammals and reptiles (46% and 48% of the species, respectively).

Other taxa that deviate from the pattern indicated across all taxa include birds, where 65% of the species were adversely affected by interspecific interactions, and amphibians, where nearly 30% cited natural causes as an important factor contributing to endangerment. The pattern associated with amphibians must be interpreted with caution, because there are only 11 amphibian species afforded protection under the ESA.

Other than indicating the overwhelming effect of habitat loss on species endangerment, few insights can be gained by this general factor typology. A more detailed account of the actual land use activities or biological agents contibuting to endangerment was addressed through specific reason categories. Under the reason categorization, agricultural development was the most frequent cause of habitat loss or habitat alteration (table 5); and agricultural development

Table 5.—Number of threatened and endangered species by specific reasons contributing to their endangerment. Specific reasons had to affect ≥15% of the species for speciose taxa (≥20 species listed), and 25% of the species in less speciose taxa.

All T&E (667 spp.)		Plants (285 spp.)		Fish (95 spp.)		Birds (85 spp.)	
256	Agricultural Development	110	Rural/Resid./Indust. Areas	49	Exotic/Introduced Species	52	Exotic/Introduced Species
234	Exotic/Introduced Species	104	Grazing	49	Water Diversion/ Drawdown	49	Predation
228	Rural/Resid./Indust. Areas	97	Heavy Equipment	44	Channel Modification	47	Agricultural Development
187	Grazing	90	Agricultural Development	42	Competition	45	Veg. Composition Changes
176	Low Gene Pool	84	Low Gene Pool	43	Environ. Contaminants/ Pollution	34	Forest Clearing
173	Predation	81	Highways/Railroads	41	Agricultural Development	31	Grazing
168	Veg. Composition Changes	76	Exotic/Introduced Species	37	Sedimentation	31	Rural/Resid./Indust. Areas
165	Heavy Equipment	69	Collecting	36	Predation	30	Forest Alteration
160	Competition	69	Recreational Areas	34	Reservoirs	28	Disease
157	Forest Clearing	69	Veg. Composition Changes	31	Erosion	25	Competition
147	Highways/Railroads	65	Competition	26	Groundwater Drawdown	24	Harassment/Indiscr. Killing
138	Erosion	62	Forest Clearing	25	Passage Barriers	19	Adverse Weather
136	Recreational Areas	56	Off-Road Vehicles	25	Water Temperature Fluctuation	19	Low Gene Pool
127	Channel Modification	54	Surface Mines	23	Bank Modification/ Devel.	18	Fire
124	Collecting	53	Erosion	22	Water Level Fluctuation	18	Food Supply Reduction
120	Forest Alteration	43	Forest Alteration	21	Hybridization	18	Parasites
115	Water Diversion/ Drawdown			20	Low Gene Pool	18	Wetland Filling
114	Surface Mines			19	Grazing	16	Pesticides
				17	Flooding	16	Recreational Areas
				17	Surface Mines	15	Shoreline Modif./Devel.
						14	Channel Modification
						14	Heavy Equipment
						14	Highways/Railroads
						14	Subsistence Hunting
						13	Erosion

Mammals (68 spp.)		Clams (42 spp.)		Reptiles (33 spp.)		Insects (22 spp.)	
25	Rural/Resid./Indust. Areas	36	Channel Modification	16	Predation	15	Rural/Resid./Indust. Areas
23	Agricultural Development	34	Sedimentation	14	Commercial Exploitation	10	Veg. Composition Changes
21	Forest Clearing	32	Environ. Contaminants/ Pollution	12	Exotic/Introduced Species	9	Grazing
19	Predation	24	Agricultural Development	12	Incidental Capture/ Killing	8	Agricultural Development
19	Recreational Areas	24	Reservoirs	11	Collecting	8	Exotic/Introduced Species
19	Veg. Composition Changes	24	Water Level Fluctuations	10	Rural/Resid./Indust. Areas	8	Heavy Equipment
17	Highways/Railroads	23	Herbicides	9	Agricultural Development	7	Highways/Railroads
16	Forest Alteration	23	Pesticides	9	Environ. Contaminants/ Pollution	7	Low Gene Pool
16	Heavy Equipment	23	Surface Mines	9	Forest Clearing	6	Fire Suppression
15	Food Supply Reduction	22	Passage Barriers	9	Harassment/Indiscr. Killing	6	Food Supply Reduction
14	Exotic/Introduced Species	20	Erosion	9	Shoreline Modif./Devel.	6	Recreational Areas
14	Harassment/Indiscr. Killing	19	Water Temperature Alteration	7	Channel Modification	5	Adverse Weather
14	Low Gene Pool	18	Inherent Reproductive Characteristics	7	Erosion	5	Collecting
14	Poaching	17	Dissolved Oxygen Reduction	7	Highways/Railroads	5	Surface Mines
13	Competition	17	Exotic/Introduced Species	7	Poaching	4	Fire
11	Incidental Capture/ Killing	17	Low Gene Pool	7	Recreational Areas	4	Off-Road Vehicles
10	Commercial Exploitation	13	Underground Mines	6	Adverse Weather	4	Pesticides
10	Grazing	9	Collecting	6	Grazing		
		8	Fertilizers	6	Inherent Reproductive Characteristics		
		7	Water Diversion/ Drawdown	6	Off-Road Vehicles		
				6	Subsistence Hunting		
				5	Fire Suppression		
				5	Forest Alteration		
				5	Reservoirs		
				5	Wetland Filling		

(continued)

Table 5.—(Continued).

Snails (13 spp.)		Amphibians (11 spp.)		Crustaceans (10 spp.)		Arachnids (3 spp.)	
6	Collecting	7	Agricultural Development	8	Environ. Contaminants/ Pollution	3	Environ. Contaminants/ Pollution
6	Forest Alteration	7	Rural/Resid./Industr. Areas	5	Sedimentation	3	Exotic/Introduced Species
6	Forest Clearing	5	Highways/Railroads	4	Agricultural Development	3	Rural/Resid./Indust. Areas
5	Hiking/Camping	5	Low Gene Pools	4	Collecting		
5	Low Gene Pool	4	Grazing	4	Herbicides		
4	Grazing	3	Adverse Weather	4	Rural/Resid./Indust. Areas		
4	Highways/Railroads	3	Collecting	3	Flooding		
4	Predation	3	Food Supply Reduction	3	Forest Clearing		
4	Recreational Areas	3	Forest Clearing	3	Gas/Oil Development		
4	Rock Climbing	3	Groundwater Drawdown	3	Heavy Equipment		
4	Rural/Resid./Indust. Areas	3	Heavy Equipment	3	Highways/Railroads		
		3	Inherent Reproductive Charact.	3	Low Gene Pool		
		3	Predation	3	Predation		
		3	Veg. Composition Changes	3	Spelunking		
		3	Water Diversion/ Drawdown	3	Surface Drainage		
				3	Water Diversion/ Drawdown		

was a prominent reason for endangerment among most taxa (particularly mammals and amphibians).

Detrimental interspecific interactions associated with introduced species was the second most frequently cited cause of species endangerment. The impact of nonnative species on species persistence was the primary factor among fish, birds, and arachnids, and was prominent among plants, reptiles, and insects.

Human overuse was primarily associated with commercial exploitation and collecting. These two activities were particularly detrimental to snails, reptiles, crustaceans, amphibians, and plants. Subsistence hunting was a less frequent reason contributing to species endangerment; but it did affect more than 15% of bird and reptile species.

Other important factors contributing to species endangerment among the taxa include grazing (plants), sedimentation (clams), predation (reptiles), forest management (snails), and environmental contaminants/pollution (crustaceans).

Land Ownership Patterns of Listed Species

Management of threatened and endangered species and recovery plan implementation is affected by the land ownership where listed species occur. Our estimates of species occurrence on public lands is based on published sources indicating occurrence on various federal ownerships, and, therefore, probably represents a minimum estimate of species occurrence on these lands. We did not include species that were identified as potentially occurring on public lands, or species that do not occur on public ownership but may be affected by management on public lands.

The two agencies that account for the majority of federally-owned lands, the U.S. Forest Service (about 77 million ha) and the Bureau of Land Management (about 109 million ha), supported 24% and 17% of the species in the database, respectively (fig. 3). Of the remaining federal agencies, the number of threatened and endangered species that occurred on Department of Defense lands was disproportionately high—26% of the species on 3.4% of the federally-administered land area. With the authorization to acquire refuge lands for endangered species conservation, a disproportionately high number of threatened and endangered species also occur on Fish and Wildlife Service lands—a pattern attributable more to animal than plant species occurrence.

County-Level Distribution of Listed Species

Endangered species are not evenly distributed across the conterminous U.S. There are distinct regions where the number of threatened and endangered species is high relative to the majority of the

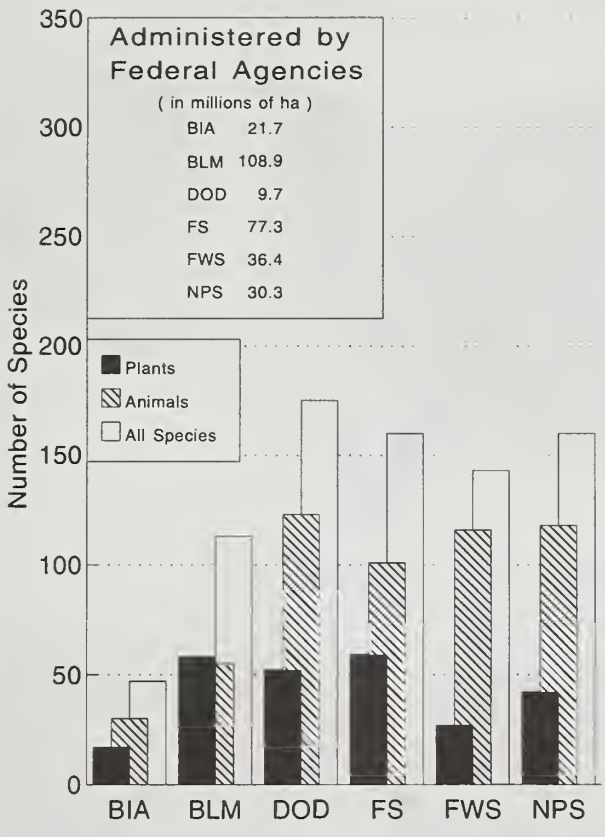


Figure 3.—Number of species occurring on federal- and state-owned lands (BIA—Bureau of Indian Affairs, BLM—Bureau of Land Management, DOD—Department of Defense, FS—Forest Service, FWS—Fish and Wildlife Service, NPS—National Park Service).

land area (fig. 4a). Southern Appalachia, Florida, and the arid Southwest were prominent regions that support a particularly high number of threatened and endangered species. In interpreting this pattern, it is important to note that the county-level occurrence of listed species is based on a compilation of published or documented accounts of the current distribution. Consequently, the extirpation of some threatened and endangered species from some regional biota (e.g., wolf [*Canis lupus*], and black-footed ferret [*Mustela nigripes*] from the Great Plains) is not accounted for in this depiction of species endangerment.

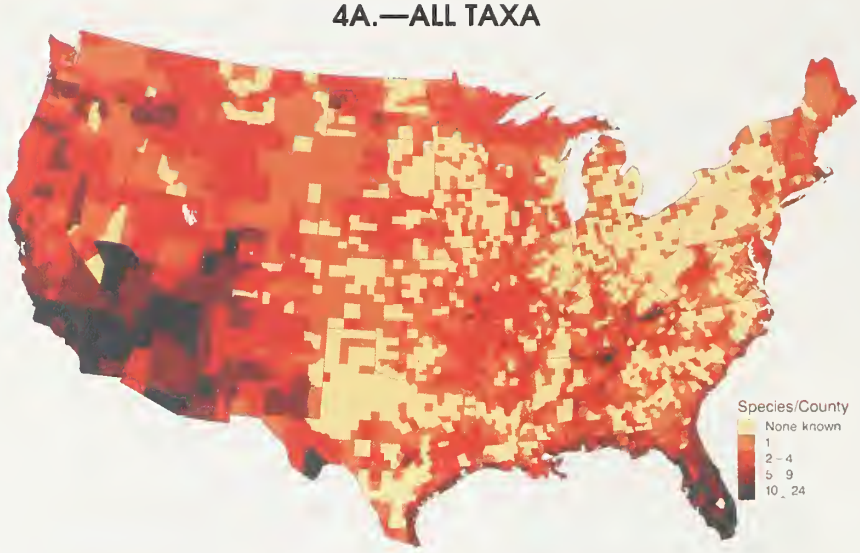
Regions of high species endangerment vary in their relative emphasis among taxa. At the kingdom level, threatened and endangered animal species are more widespread than plants (fig. 4b,c)—a pattern that is explained, in part, by the prevalence of endemism among plant species. Many rare and endangered plant species have restricted distributions and are narrowly endemic (Falk 1990, 1992). Consequently, many of the eastern counties support a single species of endangered plant that is known to occur only in that county or very few counties. This pattern is lost somewhat in the arid Southwest, where the larger counties encompass the isolated distribution of several species. One notable exception to this pattern is south-central Florida, where a high density (plants/county) of endangered plants are supported in association with sand pine scrub vegetation. Comprised of sand pine *(Pinus clausa)* and shrubby evergreen oaks (*Quercus* spp.), the sand pine/evergreen oak scrub plant community is one of the most distinctive natural communities of Florida, requiring periodic disturbance (usually fire) to maintain this species composition (USDI, Fish and Wildlife Service 1986).

Among vertebrate taxa (fig. 5), birds are the most widespread, because of their greater vagility, long-distance dispersal, and migratory capability. The concentration of avian endangerment in the Florida peninsula and central and southern California spans the avian diversity gradient for the conterminous U.S. The Florida peninsula supports the fewest number of breeding terrestrial bird species (90-100 species); the highest number of breeding bird species is found in California (180-210 species) (Cook 1969). Consequently, the concentration of endangered birds in California may be associated with the inherently greater diversity in this region. The concentration in the Florida peninsula is likely a result of the relatively high human-caused stress on natural ecosystems in this State.

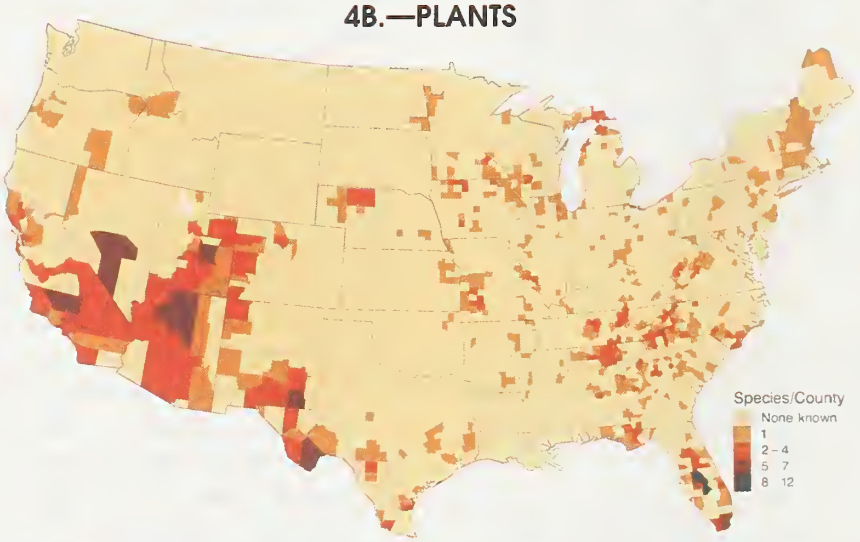
The continental pattern in mammalian diversity is similar to birds—minimum species richness in peninsular Florida, and maximum richness along the Sierra Nevada cordillera (Simpson 1964). This pattern, however, does not appear to offer any insights into regions of high mammalian endangerment. Regions supporting the greatest number of endangered mammals (coastal areas in Florida and in southern California) were, in large part, comprised of small mammals associated with dune and marsh habitats. Secondary concentrations of endangered mammalian species occurred in the northern Rocky Mountains (large ungulate and carnivores) and Appalachia (volant mammals).

Among vertebrates, the pattern in fish species endangerment is distinctive in its concentration in

4A.—ALL TAXA



4B.—PLANTS



4C.—ANIMALS

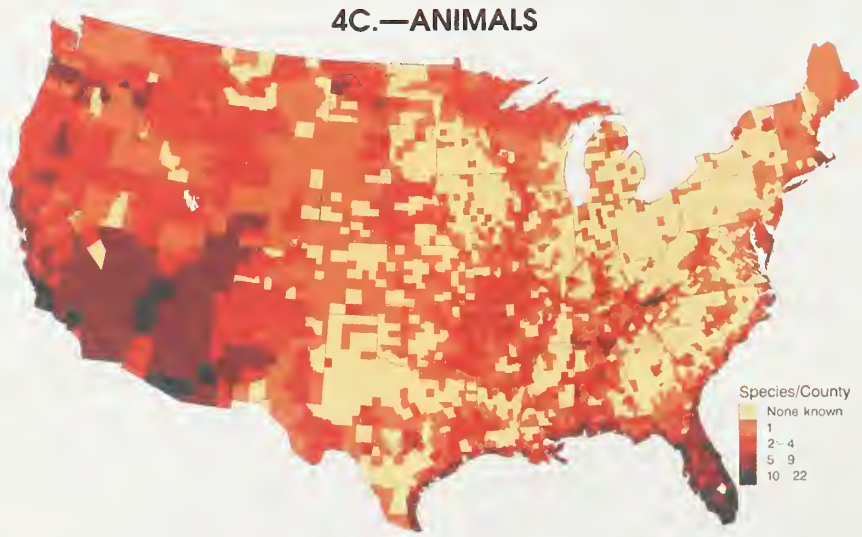
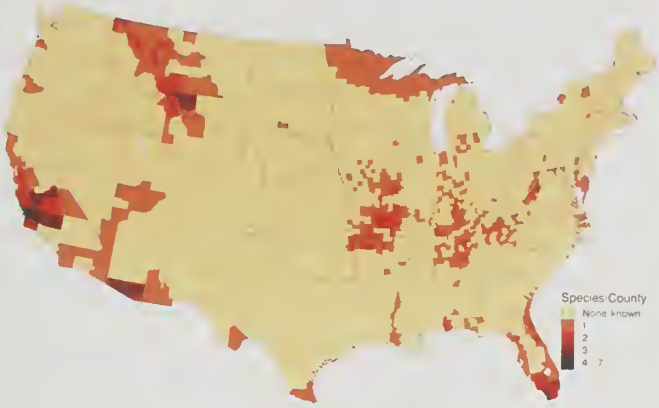
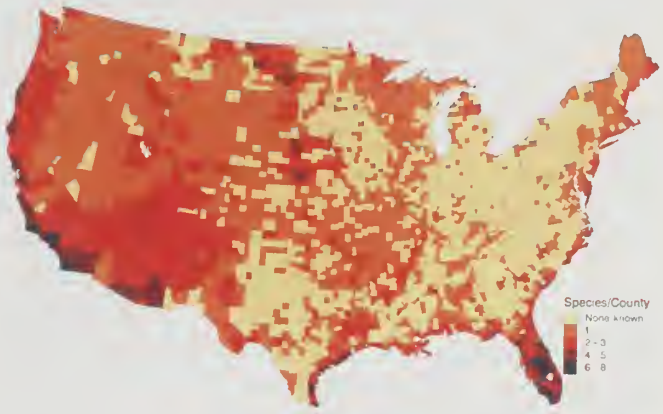


Figure 4.—Number of threatened and endangered species/county for the conterminous U.S.; all taxa (a), plants (b), and animals (c).

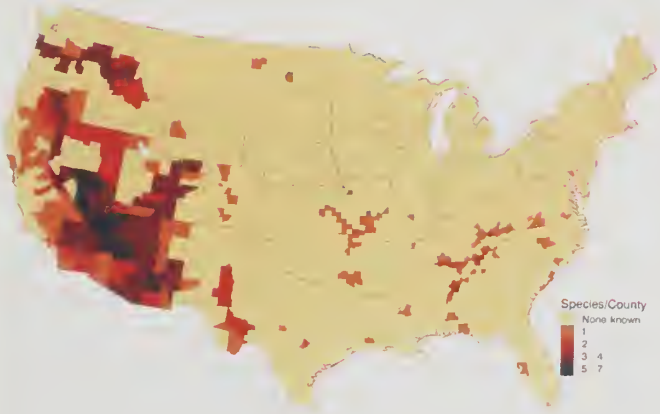
5A.—MAMMALS



5B.—BIRDS



5C.—FISH



5D.—REPTILES

5E.—AMPHIBIANS

Figure 5.—Number of threatened and endangered species/county by vertebrate taxa for the conterminous U.S.

the southwestern U.S. Although the western portion of North America only accounts for about one-quarter of the continental fish species richness, this region contains a great many species with restricted geographic distributions (Smith 1981, Sheldon 1988, Williams and Miller 1990), and is known for the prevalence of endemic species (Williams et al. 1989, Moyle and Leidy 1992). The secondary concentration of threatened and endangered fish in the southern Appalachians also is noted as an area of high endemism (Williams et al. 1989). Conversely, the speciose Midwest (Williams et al. 1989) lacks any notable concentration of endangered fish.

There is evidence that endangerment of reptiles is associated with regions of high reptilian richness. Kiester (1971) and Currie (1991) found an increase in reptilian species density along a northwest-southeast gradient. The concentration of endangered reptiles in Florida and along the Gulf coast is consistent with the general pattern of species richness. However, endangered reptiles are concentrated along the Florida coast, in particular, the south Florida coast, where Kiester (1971) observed one-third fewer reptiles compared to northern Florida. In addition, with the exception of Nueces County, Texas, along the Gulf coast, there are very few endangered reptiles in the region supporting the greatest density of reptilia in the conterminous U.S. (southeastern Texas) (Kiester 1971, fig. 4; Currie 1991, fig. 1D).

Endangerment patterns among amphibians are difficult to interpret, because so few species are formally listed as threatened or endangered. There is a lack of information on the size of amphibian populations (Barinaga 1990). However, it is notable that, of the approximately 60 amphibian species that occur in the southern Appalachians (Kiester 1971, fig. 3; Currie 1991, fig. 1C), —the greatest density of amphibia in the conterminous U.S. — none receive formal protection under the ESA.

Like amphibians, invertebrates have few species which are formally listed under the ESA. The one taxon that deviated from this pattern was freshwater bivalve mollusks (fig. 6). This taxon is relatively well studied compared to other invertebrates, and they reach their greatest richness in large river and drainage lake systems in the eastern U.S. (Pennak 1978:745, 747). The once diverse freshwater mussel fauna of the southern Appalachian lotic systems (Palmer 1986, Hafernik 1992) has the greatest concentration of endangered species.

The arthropoda (includes insects and crustaceans) was a group most characterized by the apparent lack of endangered fauna. This is the most diverse of all taxa (Erwin 1988, Gaston 1991, Pimentel et al. 1992); yet, only 33 species (23 insects, 10 crustaceans) receive formal protection under the ESA. Like some of the more obscure vertebrates, this group was characterized by restricted distributions, associations with unique habitats, and limited vagility (Hafernik 1992). The narrow endemism characteristic of this group is also a function of evolved mutualistic relations with plants—many species are dependent upon a single or a few plant species as larval hosts. The only notable concentration of endangered arthropods occurs along the central California Coast Range and valleys. This region of high arthropod endangerment is consistent with past estimates of where many insect species have recently become extinct (Pyle et al. 1981).

SPECIES AND ENVIRONMENTAL CHARACTERISTICS OF HIGH ENDANGERMENT REGIONS

To describe the attributes of environments that supported a high number of threatened and endangered species, we refined our delineation of species endangerment regions. Land-base classification systems (Garrison et al. 1977, USDA Soil Conservation Service 1981) were used to group counties that, in addition to supporting many endangered species, had similar climate, physiography, soils, vegetation, and land use. This resulted in the identification of 10 regions of high species endangerment (fig. 7). These regions were concentrated in the southern U.S., with all but the Central Desertic Basins and Plateaus occurring south of 40° north latitude.

The link to land classification was an attempt to base identification of endangerment regions on a biological, rather than political, template (Knopf 1992). We recognize, however, that county-level distribution data is fundementally political, and constrains identification of high endangerment regions on purely ecological criteria. This constraint is particularly evident in the western United States, where large counties can include many different land classification categories.

6A.—CLAMS

6B.—SNAILS

6C.—INSECTS

6D.—CRUSTACEANS

6E.—ARACHNIDS

Figure 6.—Number of threatened and endangered species/county by invertebrate taxa for the conterminous U.S.

Species Characteristics of Endangerment Regions

Taxonomic Composition

The high endangerment regions are not homogeneous with respect to their taxonomic composition (table 6, see Appendix A for regional species lists). Terrestrial vertebrates dominate in the eastern U.S., whereas aquatic vertebrates comprise a larger proportion of the endangered fauna in the western U.S. Among regions, freshwater clams are found only in the southern Appalachian endangered fauna; insects are primarily restricted to California; and endangered plants are relatively common in peninsular Florida and the desert Southwest. Because so few amphibians, snails, crustaceans, and arachnids are formally listed, these taxa never comprise a notable proportion of the endangered fauna within any of the high endangerment regions defined.

Patterns of Endemism

An endemic species is one whose distribution is restricted to a given geographic region. Because a geographic region can be defined to be a continent, an island, or a 1-km^2 area, species qualification as an endemic is dependent upon the geographic scale of the region being defined (Rapoport 1982). For our purposes, species with highly localized distributions (i.e., restricted to a portion of a county) were termed endemic. Use of political boundaries (i.e., counties) to define patterns of endemism is not without cautions (Rabinowitz et al. 1986), the most important of which is unequal aerial extent of the units. Consequently, the extent of endemism in the eastern U.S., under our criterion, is likely to be underestimated relative to the Western states, because of disparate size of counties between the two regions. A second caution involves the distribution of aquatic species where shared county boudaries along rivers would disqualify species (under our single-county criterion) with very local distributions. Data on the distribution of many species, particularly the more obscure taxa, is insufficient to permit a more detailed analysis of endemism.

County-level endemics comprise at least 25% of the endangered biota in Peninsular Florida, Southern Desertic Basins, Plains, and Mountains, Southern Nevada/Sonoran Basin, and both endangerment regions in California (table 6). Because many rare plants exhibit restricted distributions (Falk 1992), plants comprise more than 35% of the endemics in these regions. Other taxa that contributed to these areas of high endemism include mammals in Peninsular Florida (6 species), fish in Southern Nevada/Sonoran Basin (8 species), and insects in both California regions (7 species).

Despite the noted potential biases in assessing patterns of endemism based on a county-level criterion, the observed regions of high proportional endemism among endangered biota corresponded to independent evaluations of endemism among plant species. The regions of high species endangerment that also were characterized by high proportional endemism are included in the regions of high plant species endemism identified by Gentry (1986:155). Although the patterns are coarse and the correspondence qualitative, the consistency among independent efforts adds confidence in the patterns of endemism identified based on county-level occurrence of species formally listed as threatened and endangered.

Figure 7.—Delineation of species endangerment regions.

Environmental Characteristics of Endangerment Regions

Climate Description

National Weather Service monthly temperature and precipitation data were obtained[4] for stations occurring within regions of high species endanger-

[4]*Data acquired from WeatherDisc Associates, Inc., 4584 N.E. 89th, Seattle, Washington 98115.*

Table 6.—Taxonomic composition of high endangerment regions (see Appendix A for species lists).

	Southern Appalachia	Peninsular Florida	Eastern Gulf Coast	Southern Desertic Basins, Plains, and Mountains	Arizona Basin	Colorado/ Green River Plateaus	Central Desertic Basins and Plateaus	Southern Nevada/ Sonoran Basin	Central/ Southern California	Northern California
Mammals	3	10	4	1	4	1		3	8	3
Birds	1	10	7	5	6	4	3	6	11	7
Fish	6	1	1	6	9	6	4	23	6	1
Reptiles		11	8					2	4	1
Amphibians								1	1	
Vertebrates	10	32	20	12	19	11	7	35	30	12
Clams	17									
Snails		1		2		1				
Insects		1						1	5	7
Crustaceans	1	1		1						1
Invertebrates	18	3		3		1		1	5	8
Animals	28	35	20	15	19	12	7	36	35	20
Plants	11	29	7	17	8	17	11	17	14	12
Total	39	64	27	32	27	29	18	53	49	32
Endemics[1]										
Total	2	17	2	15	5	7	4	20	16	13
Plant	1	10		10	2	7	4	7	11	7

[1]*Endemics refers to species whose range is thought to be restricted to a single county.*

ment. Thirty-year (1951-1980) monthly means were averaged across stations to estimate region-specific expected temperature and precipitation throughout the year. Temporal variation in temperature was estimated by averaging 30-year mean standard deviations across stations, and calculating a region-wide annual and monthly coefficient of variation ($s/\bar{x}$). Temporal variation in precipitation was estimated as an index of dispersion, based on the quotient of the range and mean total precipitation over the 30-year period, for the year and for each month. An estimate of spatial variability within endangerment regions was based on the coefficient of variation of mean temperature and of total precipitation among stations.

Regions of high endangerment spanned the maritimity-continentality continuum (Critchfield 1983:146). The coastal regions of the southeastern and western U.S. were characterized by low seasonal variation in temperature relative to precipitation, as is typical of maritime climates (fig. 8). Conversely, the continental clime of the Southwest desert regions was characterized by high seasonal variation in temperature. The Southern Appalachian region, and to a lesser degree the eastern Gulf Coast, was unique among high endangerment regions in having equitable seasonal variation in temperature and precipitation.

Temporal variation in total precipitation indicated that there was a tendency for regions with low seasonal variation in precipitation (fig. 8) to have high annual variation in precipitation (table 7). The index of dispersion in the southwestern arid lands was 1.23-1.78, whereas the index in eastern regions was <1.0 (table 7).

Endangerment regions characterized by high temporal variation in temperature and precipitation tended to also be characterized by high spatial variation in these climate attributes (table 7). The greatest spatial variation in both temperature and precipitation occurred in the Southern Nevada/Sonoran Basin region. Relative to the arid Southwest, endangerment regions in the East showed very little spatial variability.

Ecological climate diagrams (Walter 1979:25) for endangerment regions permitted an evaluation of the intensity and seasonal extent of drought conditions. Plotting temperature and precipitation on a scale of 10°C = 20 mm precipitation permits the identification of drought-stress periods, where the temperature curve exceeds the precipitation curve

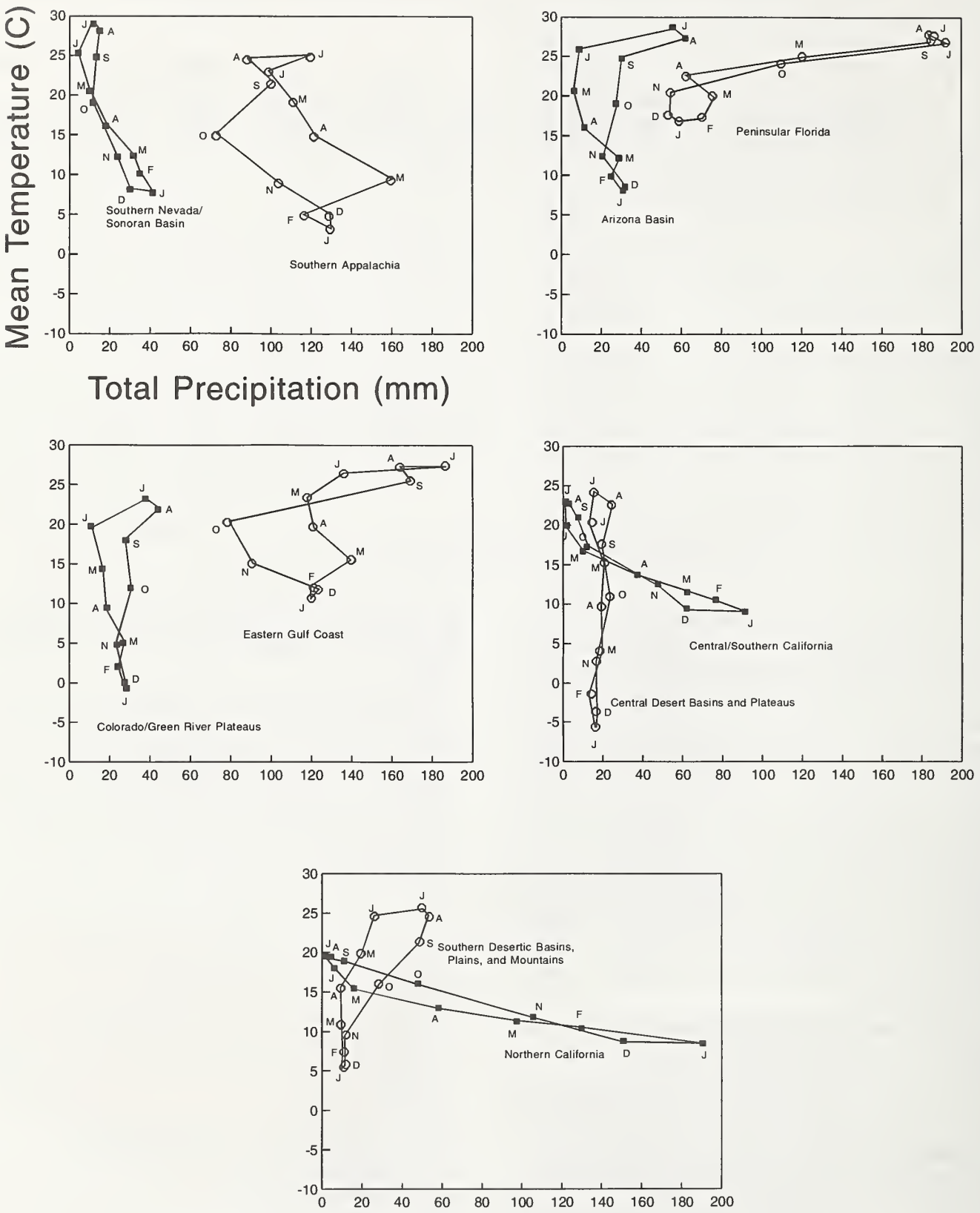


Figure 8.—Hythergraphs (Critchfield 1983:189) for regions of high species endangerment.

Table 7.—Temporal and spatial variation in temperature and precipitation among regions of high endangerment. Months where the maximum (Max) and minimum (Min) variation was observed are identified.

	Southern Appalachia	Peninsular Florida	Eastern Gulf Coast	Southern Desertic Basins, Plains, and Mountains	Arizona Basin	Colorado/ Green River Plateaus	Central Desertic Basins and Plateaus	Southern Nevada/ Sonoran Basin	Central/ Southern California	Northern California
Temporal Variation										
CV (Temp.)	0.24	0.11	0.15	0.18	0.15	0.21	0.30	0.15	0.17	0.16
Max CV	1.38	0.62	0.95	0.67	0.70	1.32	2.87	0.67	0.58	0.52
(Month)	(Jan)	(Feb)	(Jan)	(Dec)	(Feb)	(Jan)	(Jan)	(Feb)	(Dec)	(Dec)
Min CV	0.26	0.10	0.15	0.27	0.20	0.22	0.19	0.21	0.26	0.23
(Month)	(Aug)	(Aug)	(Jun)	(Aug)	(Jul)	(Jul)	(Jul)	(Jul)	(Jul)	(Jul)
ID[1] (Precip.)	0.57	0.80	0.90	1.42	1.32	1.23	1.28	1.78	1.65	1.14
Max ID	2.47	3.78	3.71	5.73	5.73	5.16	4.27	7.28	14.59	18.25
(Month)	(Oct)	(Mar)	(Oct)	(Nov)	(Jun)	(Oct)	(Jun)	(Sep)	(Aug)	(Jul)
Min ID	1.63	1.62	2.05	2.73	3.45	2.47	2.60	3.92	3.67	2.29
(Month)	(Jan)	(Aug)	(Aug)	(Aug)	(Jan)	(Jul)	(Apr)	(Mar)	(Jan)	(Jan)
Spatial Variation										
CV (Temp.)	0.03	0.02	0.01	0.08	0.10	0.09	0.08	0.12	0.07	0.03
Max CV	0.06	0.05	0.02	0.10	0.13	0.15	0.25	0.17	0.11	0.09
(Month)	(Feb)	(Dec)	(Dec)	(Dec)	(Jan)	(Jan)	(Jan)	(Jan)	(Jan)	(Jul)
Min CV	0.02	0.01	<0.01	0.07	0.08	0.08	0.05	0.10	0.06	0.04
(Month)	(Jul)	(Aug)	(Aug)	(Jul)	(Jul)	(Jul)	(Jul)	(Aug)	(Oct)	(Mar)
CV (Precip.)	0.06	0.09	0.06	0.25	0.34	0.43	0.33	0.75	0.48	0.40
Max CV	0.14	0.44	0.15	0.61	0.58	0.62	0.45	1.04	1.76	0.70
(Month)	(Sep)	(Oct)	(May)	(May)	(May)	(Feb)	(Apr)	(Jun)	(Jul)	(Aug)
Min CV	0.06	0.15	0.09	0.21	0.31	0.30	0.24	0.47	0.47	0.36
(Month)	(Nov)	(Jul)	(Feb)	(Oct)	(Oct)	(Jun)	(Oct)	(Sep)	(Nov)	(Apr)

[1]*ID = Index of dispersion calculated as the quotient of the range and mean of total annual precipitation over a 30-year period.*

(Walter 1979:28). All regions of high endangerment in the East were characterized by humid conditions throughout the year, whereas all Western regions had at least some period of drought stress (fig. 9).

Although the climate among regions of high species endangerment is not consistent, these data suggested patterns of association between endangerment and climate. Divergent variation in temperature and precipitation (i.e., variable in one but not both) was characteristic of many regions. Environmental variation has been shown to be an important factor affecting life history strategies among the biota inhabiting a region (Lui and Godt 1983, Neilson 1986, McPeek and Holt 1992). By affecting characteristics such as dispersal capability, spatial and temporal variation in climate may explain the prevalence of endemism within certain regions of the Country.

Land-Type Associations

The distribution of threatened and endangered plant and animal species with particular land-type associations mimics the distribution of terrestrial land types nation-wide. In general, regions of high species endangerment in the eastern U.S. were associated with forest ecosystems, while those regions in the west were associated with rangeland ecosystems (table 8). More specifically, species inhabiting Southern Appalachia were associated with deciduous and mixed forest types, whereas endangered species in Peninsular Florida were associated primarily with evergreen types. In the West, associations with shrub/brush range systems predominate, with the exception of California, where associations with herbaceous range systems are equally important.

Unique habitats associated with exposed rock, salt flats, and dune habitats are conspicuous among listed species. Dune habitats in Florida and the Eastern Gulf Coast showed a particularly high association with listed species in the East. Exposed rock and dry salt flats support a high number of endangered species in the arid Southwest, particularly in southern Nevada and southern California.

Patterns of association among aquatic systems are equally prominent between eastern and western endangerment regions (table 8). More than three-quarters of the endangered species in Southern Appalachia were associated with water—in particular, lotic systems. Other regions where at least 50% of the species were associated with water habitats include the Eastern Gulf Coast and the Southern Nevada/Sonoran Basin.

Although wetland habitats are relatively rare, or perhaps because they are rare, they represent a particularly important habitat type to endangered species. More than 50% of the species found in Northern California, Southern Nevada/Sonoran Basin, and the Eastern Gulf Coast were associated with wetland habitats. The concentration of wetland associated species in the arid Southwest can be traced to historical biogeography. Many of these wetland systems represent Pleistocene relics from a period when the region was characterized by a wetter climate. Because these wetland systems are embedded in a climatically harsh landscape (figs. 8 and 9), they have been effectively isolated, leading to the development of unique flora and fauna (Williams and Sada 1985, Williams et al. 1989, Hallock 1991).

Reasons for Species Endangerment

Past and current reasons thought to contribute to species endangerment varied among most regions (table 9). Penisular Florida, the Eastern Gulf Coast, and Central/Southern California all shared urban development as the most frequently cited reasons contributing to species endangerment. Grazing was

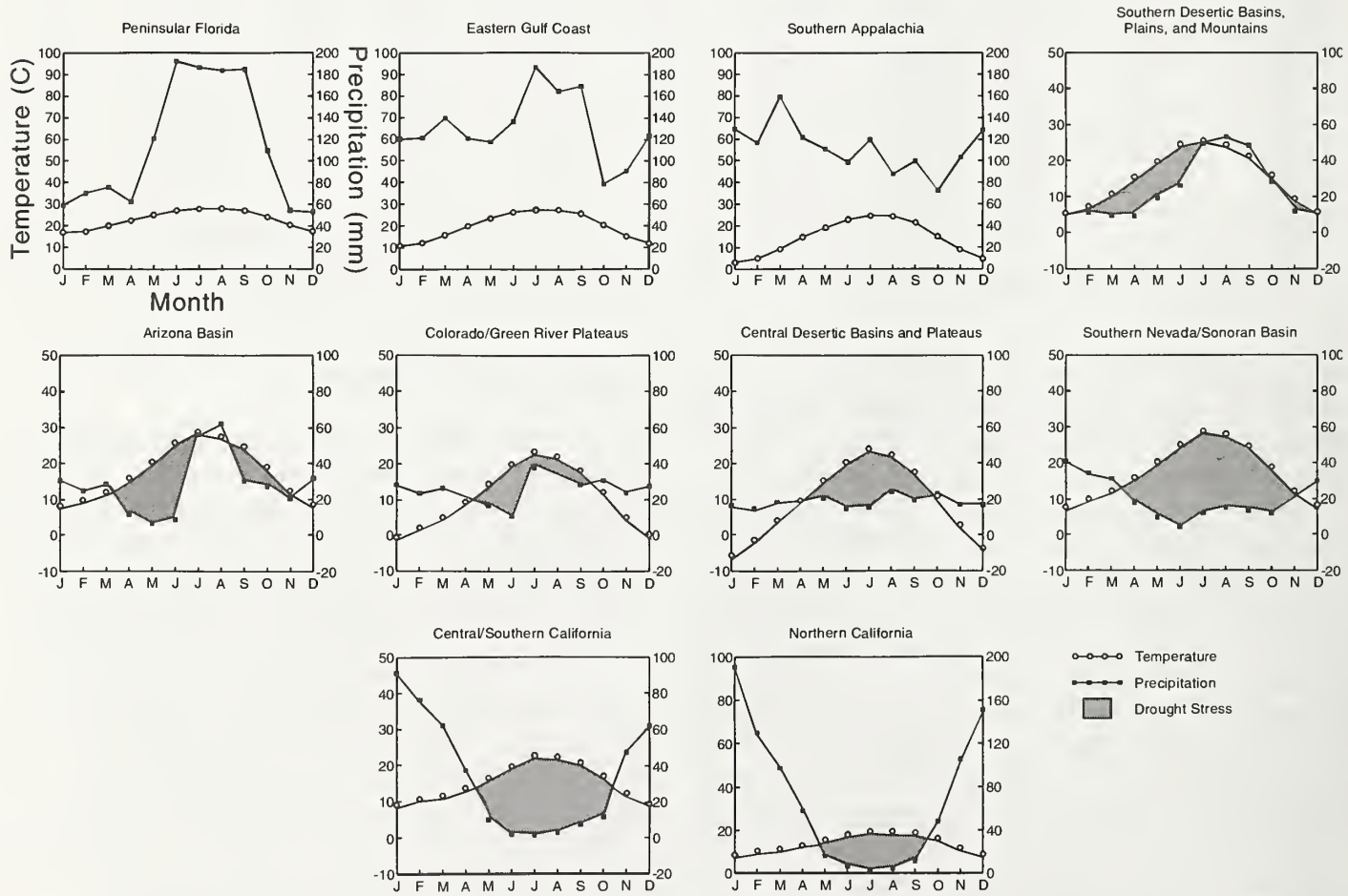


Figure 9.—Ecological climate diagrams (Walter 1979:25) for regions of high species endangerment.

Table 8.—Land-type associations among species comprising regions of high species endangerment.

Land-type	Southern Appalachia (39 spp.)	Peninsular Florida (64 spp.)	Eastern Gulf Coast (27 spp.)	Southern Desertic Basins, Plains, and Mountains (32 spp.)	Arizona Basin (27 spp.)	Colorado/ Green River Plateaus (29 spp.)	Central Desertic Basins and Plateaus (18 spp.)	Southern Nevada/ Sonoran Basin (53 spp.)	Central/ Southern California (49 spp.)	Northern California (32 spp.)
Forest	25	41	17	7	12	10	6	9	7	12
Deciduous	19	11	5	2	4	4	3	5	3	2
Evergreen	7	32	11	5	11	8	5	7	7	11
Mixed	14	13	10	5	9	7	3	4	3	5
Rangeland	3	11	6	29	21	21	15	44	34	16
Herbaceous	3	7	5	9	7	6	2	16	20	11
Shrub/Brush	1	8	3	22	17	17	10	42	24	7
Mixed	1	5	4	5	11	8	9	9	13	7
Barren	7	22	15	9	9	10	4	14	23	12
Beaches	1	11	10	3	2	2	2	3	8	4
Dry Salt Flats		1	2	2	1	1	1	8	6	5
Exposed Rock	2		1	5	4	7	2	3	11	3
Mines/Quarries/ Pits	4	2	1	2	3	1	1	2	5	6
Sand (not beach)		10	7			1		4	7	5
Mixed	1	1	1	3	4	5	3	2	4	2
Transition	1	3	3	2	1	1	1	2	9	6
Water	31	16	14	14	11	9	7	30	20	13
Bay/Estuary	2	12	10	3	3	2	2	5	11	6
Lakes	1	7	5	4	3	2	2	6	6	6
Reservoirs	3	7	5	7	4	6	5	12	8	7
Stream/Canal	31	10	8	14	11	8	7	28	12	9
Wetland	5	18	15	6	8	6	3	27	19	18
Forested	3	8	8	3	4	3	2	10	7	6
Nonforested	4	17	15	5	7	5	3	23	16	16

the most frequent reason cited in both the Arizona Basin and the Colorado/Green River Plateaus. Apart from these common patterns, endangerment regions showed unique combinations of reasons thought to affect extinction risk.

Endangerment regions in the East were associated with intensive human land use activities. In Southern Appalachia, agricultural development and the associated factors of aquatic contaminants and sedimentation were the most important activities leading to species rarity in this region. In Florida, general urban development, forest clearing (presumably associated with urban and agricultural development), and fire suppression all were prominent reasons shared by more than 40% of the species. The Eastern Gulf Coast was similar to the Florida peninsula in effects of human development; however, shoreline modification and development was specifically identified as the most important factor contributing to endangerment. Catastrophic weather events and human-caused mortality (intentional or incidental) also were important reasons along the Gulf Coast.

In the West, collecting rare plants (Southern Desertic Basins, Plains, and Mountains), surface mining, oil and gas development (Central Desertic Basins), exotic species, and water diversions (Southern Nevada/Sonoran Basin) were the most frequently cited causes for endangerment. Another prominent factor common to several regions in the arid West involved recreational activities, specifically off-road vehicles, which not only affect plants, but also sedentary wildlife.

FUTURE PATTERNS OF SPECIES ENDANGERMENT: THE SPATIAL DISTRIBUTION OF CANDIDATE SPECIES

If the current backlog of candidate species (more than 3,500 Category 1 and 2) were offered formal protection under the ESA, the number of threatened

Table 9.—Number of threatened or endangered species by specific reasons contributing to their endangerment within each region of high species endangerment. Specific reasons had to affect ≥ 25% of the species found in each region.

Southern Appalachia (39 spp.)

29 Environ. Contaminants/ Pollution
26 Agricultural Development
25 Sedimentation
24 Channel Modification
24 Surface Mines
22 Reservoirs
20 Pesticides
18 Passage Barriers
18 Water Temperature Alteration
17 Herbicides
16 Dissolved Oxygen Reduction
16 Erosion
16 Exotic/Introduced Species
15 Inherent Reproductive Characteristics
15 Low Gene Pool
14 Forest Clearing
14 Water level Fluctuation
13 Collecting
13 Underground Mines

Peninsular Florida (64 spp.)

47 Rural/Resid./Indust. Areas
33 Forest Clearing
32 Agricultural Development
27 Fire Suppression
19 Heavy Equipment
19 Veg. Composition Changes
18 Recreational Areas
17 Highways/Railroads
16 Competition

Eastern Gulf Coast (27 spp.)

11 Rural/Resid./Indust. Areas
11 Shoreline Modif./Devel.
10 Harassment/Indiscr. Killing
9 Recreational Areas
8 Adverse Weather
8 Commercial Exploitation
8 Erosion
8 Forest Alteration
8 Forest Clearing
8 Incidental Capture/Killing
8 Off-Road Vehicles
8 Predation
7 Agricultural Development
7 Channel Modification
7 Collecting
7 Environ. Contaminants/ Pollution
7 Exotic/Introduced Species

Southern Desertic Basins, Plains, and Mountains (32 spp.)

13 Collecting
12 Recreational Areas
11 Grazing
11 Highways/Railroads
10 Commercial Exploitation
10 Heavy Equipment
10 Water Diversion/Draw-down
9 Competition
8 Exotic/Introduced Species

Arizona Basin (27 spp.)

15 Grazing
11 Erosion
10 Exotic/Introduced Species
10 Predation
10 Surface Mines
9 Heavy Equipment
8 Competition
8 Forest Alteration
8 Veg. Composition Changes
7 Agricultural Development
7 Flooding
7 Recreational Areas
7 Reservoirs

Colorado/Green River Plateaus (29 spp.)

12 Grazing
11 Collecting
10 Off-Road Vehicles
10 Surface Mines
8 Commercial Exploitation
8 Erosion
8 Gas/Oil Development
8 Water Diversion/Draw-down
7 Competition
7 Heavy Equipment

Central Desertic Basins and Plateaus (18 spp.)

9 Surface Mines
8 Gas/Oil Development
6 Water Diversion/Draw-down
5 Collecting
5 Grazing
5 Heavy Equipment
5 Recreational Areas
5 Transmission Lines/Towers

Southern Nevada/ Sonoran Basin (53 spp.)

36 Exotic/Introduced Species
32 Water Diversion/Draw-down
23 Grazing
22 Agricultural Development
21 Channel Modification
19 Competition
19 Groundwater Drawdown
19 Predation
19 Recreational Areas
18 Rural/Resid./Indust. Areas
17 Low Gene Pool
17 Off-Road Vehicles
17 Surface Mines
16 Heavy Equipment
16 Reservoirs
15 Veg. Composition Changes
14 Highways/Railroads

Central/Southern California (49 spp.)

25 Rural/Resid./Indust. Areas
24 Agricultural Development
24 Exotic/Introduced Species
24 Grazing
23 Predation
18 Heavy Equipment
18 Off-Road Vehicles
16 Highways/Railroads
13 Gas/Oil Development
13 Surface Mines

Northern California (32 spp.)

18 Agricultural Development
18 Heavy Equipment
17 Rural/Resid./Indust. Areas
16 Grazing
15 Highways/Railroads
12 Off-Road Vehicles
11 Exotic/Introduced Species
10 Low Gene Pool
10 Recreational Areas
9 Adverse Weather
9 Food Supply Reduction
9 Veg. Composition Changes

and endangered species would increase by a factor of five. While it is unlikely that all Category 2 species would qualify for protection, even if only one-half of Category 2 species were determined to be at extinction risk, the current list would nearly triple in size. The magnitude of the candidate backlog raises an important question. Will regions of high species endangerment remain stable, expand, or will new areas become apparent?

As an initial attempt to address this question, state-level occurrence of Category 1 species was obtained from the Federal Register (USDI, Fish and Wildlife Service 1989, 1990a). The distribution of Category 1 species tended to emphasize current regions of species endangerment (fig. 10). The Southeast and Southwest remained areas where species endangerment will be concentrated.

Endangerment in California will become much more prominent in the future. A total of 182 Category 1 species occur in California. If these species are formally listed, this State will support the greatest concentration of endangered species in the conterminous U.S. The Mediterranean climate of California is noted for its diverse flora and fauna; and the prevalence of rare species, is largely a result of the variety of natural habitats (Cody 1986). Nearly one-fourth of the plant species in the U.S. and Canada are found in a region streching from southern Oregon to Baja California; and more than 2,000 of these species are endemic to this region (Myers 1990). Nearly 90% of Category 1 species occurring in California are plants; 9% of the species are equally distributed among insects, snails, fish, and mammals.

The only new region of species endangerment that may emerge in the future is the Pacific Northwest,

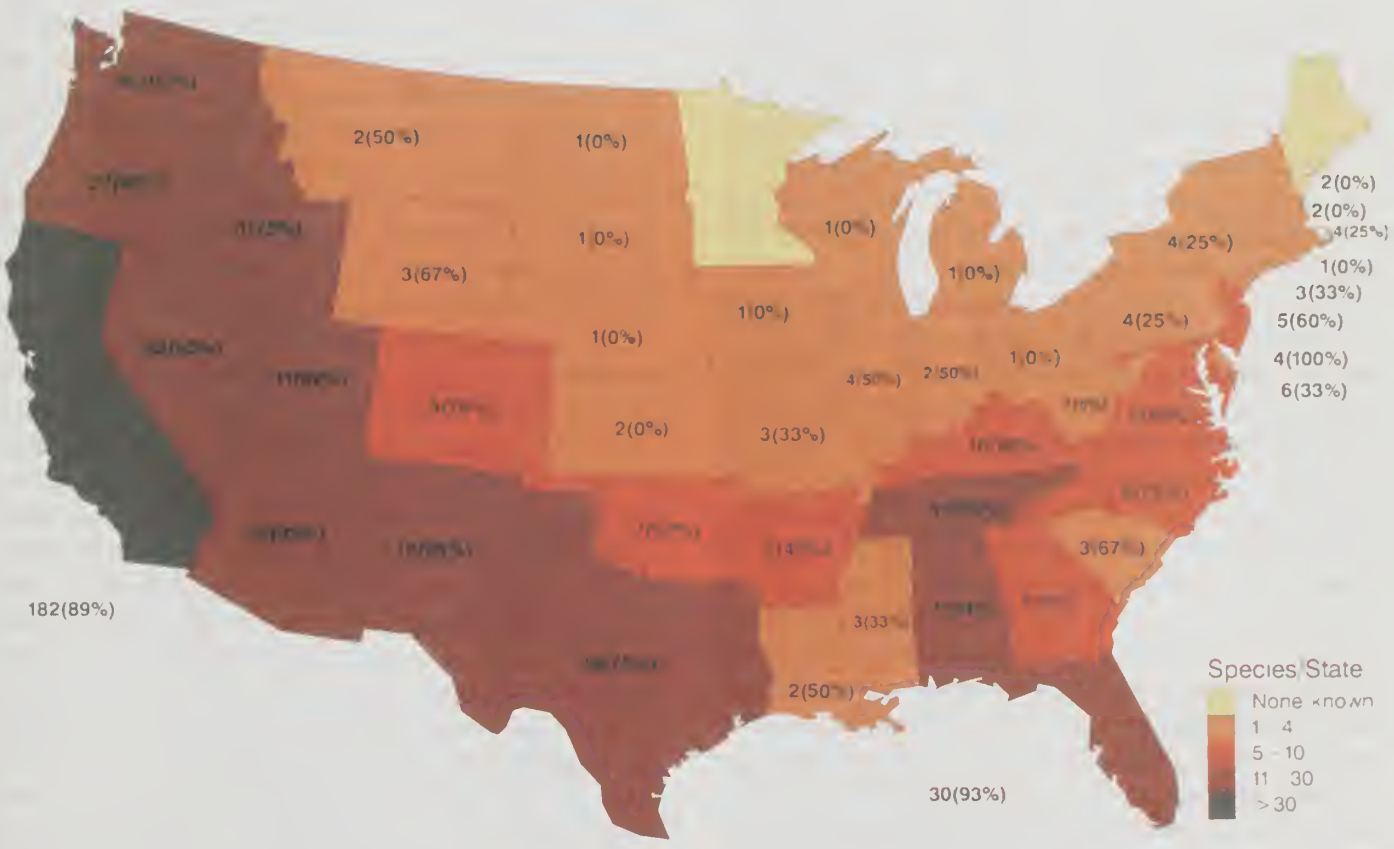


Figure 10.—Number of candidate threatened and endangered species (Category 1) by state for the conterminous U.S. The percentage of plants in each state is indicated parenthetically (USDI, Fish and Wildlife Service 1989, 1990a).

including Oregon, Washington, and Idaho. Although southwestern Oregon currently shows a moderate concentration of endangered species (fig. 4), the addition of nearly 30 species in Oregon alone should make this region of more prominent concern in the future. Like California, plants dominate the Category 1 species in this region.

The only areas of concentration among Category 1 species where plants do not comprise the majority were Nevada and New Mexico. Snails were the prominent animal taxon comprising Category 1 species in these two states.

MANAGEMENT AND POLICY IMPLICATIONS

The number of species being added to the federal list of threatened and endangered species shows no evidence of abatement. On the contrary, the rate of listing has increased over time (fig. 1), and the pool of candidate species from which future listings will be made has remained at more than 3,500 species since the mid-1980s. As noted by Bean (1988), the clearest lesson learned since passage of the ESA has been that the threat of extinction is much greater and more pervasive than was anticipated in 1973. Despite the Act's intent to reduce this risk of extinction, human activities continue to threaten and endanger a growing number of species (Scott et al. 1991).

Apart from the overall trend in species listing, another criterion for judging the success of the ESA is to ask if species protected under ESA have become less vulnerable to extirpation (Bean 1988). Forty percent of the species on the list as of 1990 had declining populations or were considered extinct (USDI, Fish and Wildlife Service 1990b:15). Given the predominance of more obscure and less ecologically well-known species among candidates for listing, recovery plans may be delayed until basic life-history information is acquired. This may lengthen the time between listing and implementation of recovery plans, increasing the likelihood of extirpation of the species (Reffalt 1988).

These trends raise important questions regarding the continued feasibility of an autecological species preservation strategy. Claims of trickle-down conservation (preservation of a single species confers implicit preservation of other species) notwithstanding (Simons et al. 1988, Pearson and Cassola 1992), if the goal of species conservation is to avert the loss of biological diversity and to slow the loss of natural systems to intense human use, then the species-by-species approach is insufficient (Norton 1987:259). Unless the underlying problems of habitat conversion and simplification are addressed by examining suites of species in context of their environment, there will be progressively more species threatened with extinction (Norton 1987:260).

An emerging trend in species conservation programs is to examine the problem from higher levels in the ecological hierarchy (species assemblages, ecosystems). The focus is on identifying and describing the characteristics of regions where endangerment is particularly prevalent, which, in turn, may permit the specification of ecological properties of species or environments that are associated with high species endangerment (Slobodkin 1986).

A common recommendation that both policy analysts and ecologists have made to address preservation and rational economic use is to define priority areas for conservation (Vane-Wright et al. 1991, Pearson and Cassola 1992:387). The data presented in this report indicate that species endangerment is not uniformly distributed across the country. The greatest potential for multiple species benefits from land acquisition or other conservation measures is in the identified regions of high species endangerment. Similarly, these regions also highlight where concern for land use conflicts should be particularly pronounced. Failure to acknowledge these conflicts could adversely affect the viability of many species.

Although regions of high species endangerment were evident, they were distinctive in their taxonomic mix, prevalence of endemism, and environmental associations. There are two important attributes of this variation among endangerment regions. First, the observed temporal and spatial variation in climatic attributes, indicated a need for management that accounts for the variability of these systems. Second, regions characterized by high endemism suggests that conservation activities may have to be implemented in small areas scattered throughout a region (Gentry 1986).

In addition to species composition and environmental differences among high endangerment regions, land ownership patterns associated with the occurrence of threatened and endangered species also have important management implications. The distribution of threatened and endangered species among federal lands indicated that no single agency

accounted for more than 27% of the listed species (fig. 3). Therefore, interagency cooperation is critical in regions where public land ownership is intermixed. However, addressing the species endangerment problem can not be relegated to public lands. Nation-wide, the most frequently cited species recovery management recommendation was land acquisition (recommended for 302 species). Incorporating the effects of private lands in a comprehensive conservation strategy is particularly important in the eastern U.S., where public lands are rare and private inholdings within the promulgated boundary of public land can be high (e.g., about 50% in the South [USDA, Forest Service 1984]).

Variation in character among endangerment regions suggests that a mix of conservation actions must be defined for each region. Management recommendations that apply to species endangerment regions in general are likely to be too broad to offer significant conservation guidance. The mix of land policy and management strategies defined for each region should be based on the particular ecology and land ownership pattern.

Concern for the Nation's endangered biota is ultimately a concern for increased species rarity. Although we have, at times, used "endangerment" and "rarity" interchangeably, it is important to note their differences. Endangerment, in our usage, has a strictly statutory basis—tied specifically to the formal listing of a species under the authority of the ESA. Although species legally designated as endangered would qualify as rare, not all rare species are listed as endangered, nor would they necessarily qualify for this legal designation. For this reason it is important, from a management perspective, that the patterns described here not be used indiscriminately to infer patterns associated with the broader notion of species rarity. Although rarity may be strongly correlated with endangerment, rarity can be defined by objective numerical criteria, whereas endangerment is based on subjective evaluations of species viability. Not until an independent assessment of rarity is completed, will the correlation between patterns reviewed here and those based on rare biota be known.

CONCLUSIONS

The Endangered Species Act of 1973 often is viewed as the strongest legislation passed by any nation to conserve biotic diversity. However, the Act has come under recent criticism for the species-by-species approach that has been used in its implementation. This criticism has emerged because the magnitude of the extinction threat was unanticipated in 1973. Since 1976, species have been listed at an average annual rate of 34 species; in the past 8 years, that rate has averaged more than 50 species. In addition, the backlog of candidate species numbered more than 3,500 in 1990. The sheer number of threatened, endangered, and candidate species raises important questions concerning the feasibility of continuing an autecological strategy to species preservation. For financial, logistic, and ecological reasons, a conservation strategy based on biological criteria above the species should be considered.

One of the empirical conclusions of this paper is that endangered biota are not homogeneously distributed across the U.S. Instead, threatened and endangered species show a strong nonrandom pattern in their occurrence, leading to distinct regions where the number of threatened and endangered species is high relative to the majority of the land base. Regions of species endangerment among taxa indicated that high intra-taxon diversity (i.e., species richness), high endemism, drought-stress climates, and land use intensification were associated, singly or in combination, with high species endangerment.

Future distributional patterns of threatened and endangered species, as indicated by the state-level distribution of candidate, Category 1 species, will emphasize present regions of species endangerment. California is notable in the concentration of Category 1 species which, if they are listed, will result in the highest concentration of endangered species in the conterminous U.S. The Pacific Northwest is likely to emerge as a new area of high species endangerment based primarily on the number of Category 1 plants occurring in this region.

Variation in the character among endangerment regions suggests that a combination of conservation activities must be defined for each region—a suite of activities that account for the idiosyncratic ecology, land ownership, and land use character of endangerment regions. Focusing land management and policy considerations on endangerment regions has the potential to increase the efficiency (e.g., multiple species benefits) with which conservation of endangered species is addressed.

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Southern Appalachia

List date	Common name	Scientific name	Taxon	Status
02/14/78	Eagle, Bald	*Haliaeetus leucocephalus*	Bird	Endangered, Threatened
06/21/90	Fanshell	*Cyprogenia stegaria*	Clam	Endangered
06/14/76	Mussel, Alabama Lamp Pearly	*Lampsilis virescens*	Clam	Endangered
06/14/76	Mussel, Appalachian Monkeyface Pearly	*Quadrula sparsa*	Clam	Endangered
06/14/76	Mussel, Birdwing Pearly	*Conradilla caelata*	Clam	Endangered
09/28/89	Mussel, Cracking Pearly	*Hemistena lata*	Clam	Endangered
06/14/76	Mussel, Cumberland Bean Pearly	*Villosa trabalis*	Clam	Endangered
06/14/76	Mussel, Cumberland Monkeyface Pearly	*Quadrula intermedia*	Clam	Endangered
06/14/76	Mussel, Dromedary Pearly	*Dromus dromas*	Clam	Endangered
06/14/76	Mussel, Green-blossom Pearly	*Epioblasma torulosa gubernaculum*	Clam	Endangered
11/14/88	Mussel, Little Wing Pearly	*Pegias fabula*	Clam	Endangered
06/14/76	Mussel, Orange-footed Pearly	*Plethobasus cooperianus*	Clam	Endangered
06/14/76	Mussel, Pale Lilliput Pearly	*Toxolasma cylindrellus*	Clam	Endangered
06/12/76	Mussel, Pink Mucket Pearly	*Lampsilis orbiculata*	Clam	Endangered
06/14/76	Pigtoe, Fine-rayed	*Fusconaia cuneolus*	Clam	Endangered
06/14/76	Pigtoe, Rough	*Pleurobema plenum*	Clam	Endangered
06/14/76	Pigtoe, Shiny	*Fusconaia edgariana*	Clam	Endangered
08/27/77	Riffle Shell, Tan	*Epioblasma walkeri*	Clam	Endangered
09/07/88	Shrimp, Alabama Cave	*Palaemonias alabamae*	Crustacean	Endangered
09/09/77	Chub, Slender	*Erimystax cahni*	Fish	Threatened
09/09/77	Chub, Spotfin	*Cyprinella monacha*	Fish	Threatened
06/12/87	Dace, Blackside	*Phoxinus cumberlandensis*	Fish	Threatened
09/09/77	Darter, Slackwater	*Etheostoma boschungi*	Fish	Threatened
07/05/84	Darter, Snail	*Percina tanasi*	Fish	Threatened
09/09/77	Madtom, Yellowfin	*Noturus flavipinnis*	Fish	Threatened
04/28/76	Bat, Gray	*Myotis grisescens*	Mammal	Endangered
03/11/67	Bat, Indiana	*Myotis sodalis*	Mammal	Endangered
07/01/85	Squirrel, Virginia Northern Flying	*Glaucomys sabrinus fuscus*	Mammal	Endangered
04/26/78	Birch, Virginia Round-leaf	*Betula uber*	Plant	Endangered
09/07/88	Button, Mohr's Barbara's	*Marshallia mohrii*	Plant	Threatened
07/14/89	Fern, American Hart's-tongue	*Phyllitis scolopendrium* var. *americana*	Plant	Threatened
09/26/86	Leather Flower, Alabama	*Clematis socialis*	Plant	Endangered
09/21/79	Pitcher-plant, Green	*Sarracenia oreophila*	Plant	Endangered
01/05/90	Potato-bean, Price's	*Apios priceana*	Plant	Threatened
01/18/91	Rosemary, Cumberland	*Conradina verticillata*	Plant	Threatened

(continued)

List date	Common name	Scientific name	Taxon	Status
06/23/88	Sandwort, Cumberland	*Arenaria cumberlandensis*	Plant	Endangered
06/20/86	Skullcap, Large-flowered	*Scutellaria montana*	Plant	Endangered
06/15/90	Spiraea, Virginia	*Spiraea virginiana*	Plant	Threatened
04/13/90	Water-plantain, Kral's	*Sagittaria secundifolia*	Plant	Threatened
Peninsular Florida				
07/06/87	Caracara, Audubon's Crested	*Polyborus plancus audubonii*	Bird	Threatened
02/14/78	Eagle, Bald	*Haliaeetus leucocephalus*	Bird	Endangered, Threatened
06/03/87	Jay, Florida Scrub	*Aphelocoma coerulescens coerulescens*	Bird	Threatened
03/11/67	Kite, Everglade Snail	*Rostrhamus sociabilis plumbeus*	Bird	Endangered
12/11/85	Plover, Piping	*Charadrius melodus*	Bird	Endangered
03/11/67	Sparrow, Cape Sable Seaside	*Ammodramus maritimus mirabilis*	Bird	Endangered
07/31/86	Sparrow, Florida Grasshopper	*Ammodramus savannarum floridanus*	Bird	Endangered
02/28/84	Stork, Wood	*Mycteria americana*	Bird	Endangered
10/02/87	Tern, Roseate	*Sterna dougallii dougallii*	Bird	Endangered, Threatened
10/13/70	Woodpecker, Red-cockaded	*Picoides borealis*	Bird	Endangered
06/21/90	Shrimp, Squirrel Chimney Cave	*Palaemonetes cummingi*	Crustacean	Threatened
09/30/91	Sturgeon, Gulf	*Acipenser oxyrhnchus desotoi*	Fish	Endangered
08/31/84	Butterfly, Schaus Swallowtail	*Heraclides aristodemus ponceanus*	Insect	Endangered
03/11/67	Deer, Key	*Odocoileus virginianus clavium*	Mammal	Endangered
03/11/67	Manatee, West Indian	*Trichechus manatus*	Mammal	Endangered
05/12/89	Mouse, Anastasia Island Beach	*Peromyscus polionotus phasma*	Mammal	Endangered
09/21/83	Mouse, Key Largo Cotton	*Peromyscus gossypinus allapaticola*	Mammal	Endangered
05/12/89	Mouse, Southeastern Beach	*Peromyscus polionotus niveiventris*	Mammal	Threatened
03/11/67	Panther, Florida	*Felis concolor coryi*	Mammal	Endangered
06/21/90	Rabbit, Lower Keys	*Sylvilagus palustris hefneri*	Mammal	Endangered
04/30/91	Rat, Rice	*Oryzomys palustris natator*	Mammal	Endangered
01/14/91	Vole, Florida Salt Marsh	*Microtus pennsylvanicus dukecampbelli*	Mammal	Endangered
09/21/83	Woodrat, Key Largo	*Neotoma floridana smalli*	Mammal	Endangered
05/16/86	Aster, Florida golden	*Chrysopsis floridana*	Plant	Endangered
07/27/89	Bellflower, Brooksville	*Campanula robinsiae*	Plant	Endangered
07/27/89	Blazingstar, Scrub	*Liatris ohlingerae*	Plant	Endangered
11/02/87	Bonamia, Florida	*Bonamia grandiflora*	Plant	Threatened
11/01/85	Cactus, Fragrant Prickly-apple	*Cereus eriophorus* var. *fragrans*	Plant	Endangered
07/19/84	Cactus, Key Tree	*Cereus robinii*	Plant	Endangered
01/21/87	Fringe Tree, Pygmy	*Chionanthus pygmaeus*	Plant	Endangered
01/21/87	Hypericum, Highlands Scrub	*Hypericum cumulicola*	Plant	Endangered
07/18/85	Lead-plant, Crenulate	*Amorpha crenulata*	Plant	Endangered

(continued)

List date	Common name	Scientific name	Taxon	Status
04/07/87	Lupine, Scrub	*Lupinus aridorum*	Plant	Endangered
07/18/85	Milkpea, Small's	*Galactia smallii*	Plant	Endangered
09/21/89	Mint, Garrett's	*Dicerandra christmanii*	Plant	Endangered
05/15/85	Mint, Lakela's	*Dicerandra immaculata*	Plant	Endangered
11/01/85	Mint, Longspurred	*Dicerandra cornutissima*	Plant	Endangered
11/01/85	Mint, Scrub	*Dicerandra frutescens*	Plant	Endangered
01/21/87	Mustard, Carter's	*Warea carteri*	Plant	Endangered
09/26/86	Pawpaw, Beautiful	*Deeringothamnus pulchellus*	Plant	Endangered
09/26/86	Pawpaw, Four-petal	*Asimina tetramera*	Plant	Endangered
09/26/86	Pawpaw, Rugel's	*Deeringothamnus rugelii*	Plant	Endangered
01/21/87	Plum, Scrub	*Prunus geniculata*	Plant	Endangered
07/18/85	Polygala, Tiny	*Polygala smallii*	Plant	Endangered
01/21/87	Snakeroot	*Eryngium cuneifolium*	Plant	Endangered
07/18/85	Spurge, Deltoid	*Chamaesyce deltoidea* ssp. *deltoidea*	Plant	Endangered
07/18/85	Spurge, Garber's	*Chamaesyce garberi*	Plant	Threatened
04/26/87	Warea, Wide-leaf	*Warea amplexifolia*	Plant	Endangered
07/27/89	Water-willow, Cooley's	*Justicia cooleyi*	Plant	Endangered
01/21/87	Whitlow-wort, Papery	*Paronychia chartacea*	Plant	Endangered
01/21/87	Wireweed	*Polygonella basiramia*	Plant	Endangered
07/27/89	Ziziphus, Florida	*Ziziphus celata*	Plant	Endangered
06/04/87	Alligator, American	*Alligator mississippiensis*	Reptile	Endangered
09/25/75	Crocodile, American	*Crocodylus acutus*	Reptile	Endangered
11/06/87	Skink, Blue-tailed Mole	*Eumeces egregrius lividus*	Reptile	Threatened
11/06/87	Skink, Sand	*Neoseps reynoldsi*	Reptile	Threatened
11/29/77	Snake, Atlantic Salt Marsh	*Nerodia fasciata taeniata*	Reptile	Threatened
01/31/78	Snake, Eastern Indigo	*Drymarchon corais couperi*	Reptile	Threatened
10/13/70	Turtle, Green Sea	*Chelonia mydas*	Reptile	Endangered, Threatened
06/02/70	Turtle, Hawksbill Sea	*Eretmochelys imbricata*	Reptile	Endangered
12/02/70	Turtle, Kemp's Ridley Sea	*Lepidochelys kempii*	Reptile	Endangered
06/02/70	Turtle, Leatherback Sea	*Dermochelys coriacea*	Reptile	Endangered
07/28/78	Turtle, Loggerhead Sea	*Caretta caretta*	Reptile	Threatened
07/03/78	Snail, Stock Island Tree	*Orthalicus reses*	Snail	Threatened
Eastern Gulf Coast				
06/04/73	Crane, Mississippi Sandhill	*Grus canadensis pulla*	Bird	Endangered
02/14/78	Eagle, Bald	*Haliaeetus leucocephalus*	Bird	Endangered, Threatened
06/03/87	Jay, Florida Scrub	*Aphelocoma coerulescens coerulescens*	Bird	Threatened
10/13/70	Pelican, Brown	*Pelecanus occidentalis*	Bird	Endangered

(continued)

List date	Common name	Scientific name	Taxon	Status
12/11/85	Plover, Piping	*Charadrius melodus*	Bird	Endangered, Threatened
02/28/84	Stork, Wood	*Mycteria americana*	Bird	Endangered
10/13/70	Woodpecker, Red-cockaded	*Picoides borealis*	Bird	Endangered
06/04/73	Darter, Okaloosa	*Etheostoma okaloosae*	Fish	Endangered
03/11/67	Manatee, West Indian	*Trichechus manatus*	Mammal	Endangered
06/06/85	Mouse, Alabama Beach	*Peromyscus polionotus ammobates*	Mammal	Endangered
06/06/85	Mouse, Choctawhatchee Beach	*Peromyscus polionotus allophrys*	Mammal	Endangered
06/06/85	Mouse, Perdido Key Beach	*Peromyscus polionotus trissyllepsis*	Mammal	Endangered
01/21/87	Fringe Tree, Pygmy	*Chionanthus pygmaeus*	Plant	Endangered
07/18/85	Gooseberry, Miccosukee	*Ribes echinellum*	Plant	Threatened
10/02/79	Harper's Beauty	*Harperocallis flava*	Plant	Endangered
02/07/89	Meadowrue, Cooley's	*Thalictrum cooleyi*	Plant	Endangered
11/26/90	Pinkroot, Gentian	*Spigelia gentianoides*	Plant	Endangered
04/24/79	Rhododendron, Chapman	*Rhododendron chapmanii*	Plant	Endangered
01/23/84	Torreya, Florida	*Torreya taxifolia*	Plant	Endangered
06/04/87	Alligator, American	*Alligator mississippiensis*	Reptile	Endangered
01/31/78	Snake, Eastern Indigo	*Drymarchon corais couperi*	Reptile	Threatened
07/07/87	Tortoise, Gopher	*Gopherus polyphemus*	Reptile	Threatened
06/17/87	Turtle, Alabama Red-bellied	*Pseudemys alabamensis*	Reptile	Endangered
10/13/70	Turtle, Green Sea	*Chelonia mydas*	Reptile	Endangered
12/02/70	Turtle, Kemp's Ridley Sea	*Lepidochelys kempii*	Reptile	Endangered
07/28/78	Turtle, Loggerhead Sea	*Caretta caretta*	Reptile	Threatened
12/23/86	Turtle, Ringed Sawback	*Graptemys oculifera*	Reptile	Threatened
Southern Desertic Basins, Plains, and Mountains				
03/11/67	Crane, Whooping	*Grus americana*	Bird	Endangered
02/14/78	Eagle, Bald	*Haliaeetus leucocephalus*	Bird	Endangered, Threatened
10/13/70	Falcon, American Peregrine	*Falco peregrinus anatum*	Bird	Endangered
05/28/85	Tern, Least	*Sterna antillarum*	Bird	Endangered
10/06/87	Vireo, Black-capped	*Vireo atricapillus*	Bird	Endangered
03/27/78	Isopod, Socorro	*Thermosphaeroma thermophilus*	Crustacean	Endangered
03/11/67	Gambusia, Big Bend	*Gambusia gaigei*	Fish	Endangered
10/13/70	Gambusia, Pecos	*Gambusia nobilis*	Fish	Endangered
03/11/67	Pupfish, Comanche Springs	*Cyprinodon elegans*	Fish	Endangered
08/15/80	Pupfish, Leon Springs	*Cyprinodon bovinus*	Fish	Endangered
02/19/87	Shiner, Pecos Bluntnose	*Notropis simus pecosensis*	Fish	Threatened
03/11/67	Trout, Gila	*Oncorhynchus gilae*	Fish	Endangered
09/30/88	Bat, Mexican Long-nosed	*Leptonycteris nivalis*	Mammal	Endangered

(continued)

List date	Common name	Scientific name	Taxon	Status
11/06/79	Cactus, Bunched Cory	*Coryphantha ramillosa*	Plant	Threatened
09/30/88	Cactus, Chisos Mountain Hedgehog	*Echinocereus chisosensis* var. *chisosensis*	Plant	Threatened
10/26/79	Cactus, Kuenzler Hedgehog	*Echinocereus fendleri* var. *kuenzleri*	Plant	Endangered
10/25/79	Cactus, Lee Pincushion	*Coryphantha sneedii* var. *leei*	Plant	Threatened
10/26/79	Cactus, Lloyd's Hedgehog	*Echinocereus lloydii*	Plant	Endangered
11/06/79	Cactus, Lloyd's Mariposa	*Neolloydia mariposensis*	Plant	Threatened
11/07/79	Cactus, Nellie Cory	*Coryphantha minima*	Plant	Endangered
11/07/79	Cactus, Sneed Pincushion	*Coryphantha sneedii* var. *sneedii*	Plant	Endangered
09/30/91	Cat's Eye, Terlingua Creek	*Cryptantha crassipes*	Plant	Endangered
08/26/88	Oak, Hinckley's	*Quercus hinckleyi*	Plant	Threatened
07/13/82	Pennyroyal, McKittrick	*Hedeoma apiculatum*	Plant	Threatened
01/19/81	Pennyroyal, Todsen's	*Hedeoma todsenii*	Plant	Endangered
11/07/79	Pitaya, Davis' Green	*Echinocereus viridiflorus* var. *davisii*	Plant	Endangered
11/14/91	Pondweed, Little Aguja	*Potamogeton clystocarpus*	Plant	Endangered
08/24/89	Prickly Poppy, Sacramento	*Argemone pleiacantha* ssp. *pinnatisecta*	Plant	Endangered
06/16/87	Thistle, Sacramento Mountains	*Cirsium vinaceum*	Plant	Threatened
01/19/81	Wild-buckwheat, Gypsum	*Eriogonum gypsophilum*	Plant	Threatened
09/30/91	Springsnail, Alamosa	*Tryonia alamosae*	Snail	Endangered
09/30/91	Springsnail, Socorro	*Pyrqulopsis neomexicana*	Snail	Endangered

Arizona Basin

03/11/67	Bobwhite, Masked	*Colinus virginianus ridgwayi*	Bird	Endangered
02/14/78	Eagle, Bald	*Haliaeetus leucocephalus*	Bird	Endangered, Threatened
10/13/70	Falcon, American Peregrine	*Falco peregrinus anatum*	Bird	Endangered
03/16/93	Owl, Mexican Spotted	*Strix occidentalis lucida*	Bird	Threatened
06/02/70	Parrot, Thick-billed	*Rhynchopsitta pachyrhyncha*	Bird	Endangered
03/11/67	Rail, Yuma Clapper	*Rallus longirostris yumanensis*	Bird	Endangered
04/30/86	Chub, Sonora	*Gila ditaenia*	Fish	Threatened
08/31/84	Chub, Yaqui	*Gila purpurea*	Fish	Endangered
10/28/86	Minnow, Loach	*Rhinicthys cobitis*	Fish	Threatened
03/31/86	Pupfish, Desert	*Cyprinodon macularius*	Fish	Endangered
07/01/86	Spikedace	*Meda fulgida*	Fish	Threatened
03/11/67	Topminnow, Gila	*Poeciliopsis occidentalis*	Fish	Endangered
03/11/67	Topminnow, Yaqui	*Poeciliopsis occidentalis*	Fish	Endangered
03/11/87	Trout, Apache	*Oncorhynchus apache*	Fish	Threatened
03/11/67	Trout, Gila	*Oncorhynchus gilae*	Fish	Endangered
09/30/88	Bat, Sanborn's Long-nosed	*Leptonycteris sanborni*	Mammal	Endangered
12/02/70	Jaguar	*Panthera onca*	Mammal	Endangered

(continued)

List date	Common name	Scientific name	Taxon	Status
03/11/67	Pronghorn, Sonoran	*Antilocapra americana sonoriensis*	Mammal	Endangered
06/03/87	Squirrel, Mount Graham Red	*Tamiasciurus hudsonicus grahamensis*	Mammal	Endangered
05/18/84	Agave, Arizona	*Agave arizonica*	Plant	Endangered
01/19/89	Blue-star, Kearney's	*Amsonia kearneyana*	Plant	Endangered
10/25/79	Cactus, Arizona Hedgehog	*Echinocereus triglochidiatus* var. *arizonicus*	Plant	Endangered
01/09/86	Cactus, Cochise Pincushion	*Coryphantha robbinsorum*	Plant	Threatened
10/26/79	Cactus, Nichol's Turk's Head	*Echinocactus horizonthalonius* var. *nicholii*	Plant	Endangered
05/29/84	Cliffrose, Arizona	*Purshia subintegra*	Plant	Endangered
04/26/85	Fleabane, Rhizome	*Erigeron rhizomatus*	Plant	Threatened
04/26/86	Globe-berry, Tumamoc	*Tumamoca macdougalii*	Plant	Endangered
Colorado/Green River Plateaus				
02/14/78	Eagle, Bald	*Haliaeetus leucocephalus*	Bird	Endangered, Threatened
10/13/70	Falcon, American Peregrine	*Falco peregrinus anatum*	Bird	Endangered
03/16/93	Owl, Mexican Spotted	*Strix occidentalis lucida*	Bird	Threatened
06/02/70	Parrot, Thick-billed	*Rhynchopsitta pachyrhyncha*	Bird	Endangered
03/11/67	Chub, Humpback	*Gila cypha*	Fish	Endangered
10/28/86	Minnow, Loach	*Rhinichthys cobitis*	Fish	Threatened
09/16/87	Spinedace, Little Colorado	*Lepidomeda vittata*	Fish	Threatened
03/11/67	Squawfish, Colorado	*Ptychocheilus lucius*	Fish	Endangered
10/23/91	Sucker, Razorback	*Xyrauchen texanus*	Fish	Endangered
03/11/87	Trout, Apache	*Oncorhynchus apache*	Fish	Threatened
05/29/84	Prairie Dog, Utah	*Cynomys parvidens*	Mammal	Threatened
07/21/89	Buttercup, Autumn	*Ranunculus acriformis* var. *aestivalis*	Plant	Endangered
10/26/79	Cactus, Brady Pincushion	*Pediocactus bradyi*	Plant	Endangered
10/26/79	Cactus, Knowlton	*Pediocactus knowltonii*	Plant	Endangered
10/30/79	Cactus, Mesa Verde	*Sclerocactus mesae-verdae*	Plant	Threatened
10/26/79	Cactus, Peebles Navajo	*Pediocactus peeblesianus* var. *peeblesianus*	Plant	Endangered
10/26/79	Cactus, Siler Pincushion	*Pediocactus sileri*	Plant	Endangered
11/07/79	Cactus, Spineless Hedgehog	*Echinocereus triglochidiatus* var. *inermis*	Plant	Endangered
10/11/79	Cactus, Wright Fishhook	*Sclerocactus wrightiae*	Plant	Endangered
05/05/86	Cycladenia, Jones	*Cycladenia humilis* var. *jonesii*	Plant	Threatened
11/22/83	Groundsel, San Francisco Peaks	*Senecio franciscanus*	Plant	Threatened
01/17/92	Ladies'-tresses, Ute	*Spiranthes diluvialis*	Plant	Threatened
06/27/85	Milk-vetch, Mancos	*Astragalus humillimus*	Plant	Endangered
12/05/90	Milk-vetch, Sentry	*Astragauls cremnophylax* var. *cremnophylax*	Plant	Endangered
10/28/87	Milkweed, Welsh's	*Asclepias welshii*	Plant	Threatened
01/14/92	Reed-Mustard, Barneby	*Schoenocrambe barnebyi*	Plant	Endangered

(continued)

List date	Common name	Scientific name	Taxon	Status
05/08/85	Sedge, Navajo	*Carex specuicola*	Plant	Threatened
08/21/85	Townsendia, Last Chance	*Townsendia aprica*	Plant	Threatened
04/17/92	Ambersnail, Kanab	*Oxyloma haydeni kanabensis*	Snail	Endangered

Central Desertic Basins and Plateaus

03/11/67	Crane, Whooping	*Grus americana*	Bird	Endangered
02/14/78	Eagle, Bald	*Haliaeetus leucocephalus*	Bird	Endangered, Threatened
10/13/70	Falcon, American Peregrine	*Galco peregrinus anatum*	Bird	Endangered
04/23/80	Chub, Bonytail	*Gila elegans*	Fish	Endangered
03/11/67	Chub, Humpback	*Gila cypha*	Fish	Endangered
03/11/67	Squawfish, Colorado	*Ptychocheilus lucius*	Fish	Endangered
10/23/91	Sucker, Razorback	*Xyrauchen texanus*	Fish	Endangered
09/16/87	Cactus, San Rafael	*Pediocactus despainii*	Plant	Endangered
11/07/79	Cactus, Spineless Hedgehog	*Echinocereus triglochidiatus* var. *inermis*	Plant	Endangered
10/11/79	Cactus, Unita Basin Hookless	*Sclerocactus glaucus*	Plant	Threatened
10/11/79	Cactus, Wright Fishhook	*Sclerocactus wrightiae*	Plant	Endangered
05/05/86	Cycladenia, Jones	*Cycladenia humilis* var. *jonesii*	Plant	Threatened
09/05/85	Daisy, Maguire	*Erigeron maguirei* var. *maguirei*	Plant	Endangered
01/17/92	Ladies'-tresses, Ute	*Spiranthes diluvialis*	Plant	Threatened
01/14/92	Reed-mustard, Barneby	*Schoenocrambe barnebyi*	Plant	Endangered
01/14/92	Reed-mustard, Clay	*Schoenocrambe argillacea*	Plant	Threatened
10/06/87	Reed-mustard, Shrubby	*Schoenocrambe suffrutescens*	Plant	Endangered
08/21/85	Townsendia, Last Chance	*Townsendia aprica*	Plant	Threatened

Southern Nevada/Sonoran Basin

06/04/73	Salamander, Desert Slender	*Batrachoseps aridus*	Amphibian	Endangered
02/14/78	Eagle, Bald	*Haliaeetus leucocephalus*	Bird	Endangered, Threatened
10/13/70	Falcon, American Peregrine	*Falco peregrinus anatum*	Bird	Endangered
10/13/70	Pelican, Brown	*Pelecanus occidentalis*	Bird	Endangered
03/11/67	Rail, Yuma Clapper	*Rallus longirostris yumanensis*	Bird	Endangered
08/03/87	Towhee, Inyo California	*Pipilo crissalis eremophilus*	Bird	Threatened
05/02/86	Vireo, Least Bell's	*Vireo bellii pusillus*	Bird	Endangered
04/23/80	Chub, Bonytail	*Gila elegans*	Fish	Endangered
10/13/70	Chub, Mohave Tui	*Gila bicolor mohavensis*	Fish	Endangered
08/05/85	Chub, Owens Tui	*Gila bicolor snyderi*	Fish	Endangered
10/13/70	Chub, Pahranagat Roundtail	*Gila robusta jordani*	Fish	Endangered
08/24/89	Chub, Virgin River	*Gila robusta semidnuda*	Fish	Endangered

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List date	Common name	Scientific name	Taxon	Status
09/02/83	Dace, Ash Meadows Speckled	*Rhinichthys osculus nevadensis*	Fish	Endangered
03/11/67	Dace, Moapa	*Moapa coriacea*	Fish	Endangered
03/11/67	Poolfish, Pahrump	*Empetrichthys latos*	Fish	Endangered
09/02/83	Pupfish, Ash Meadows Amargosa	*Cyprinodon nevadensis mionectes*	Fish	Endangered
03/31/86	Pupfish, Desert	*Cyprinodon macularius*	Fish	Endangered
03/11/67	Pupfish, Devils Hole	*Cyprinodon diabolis*	Fish	Endangered
03/11/67	Pupfish, Owens	*Cyprinodon radiosus*	Fish	Endangered
10/13/70	Pupfish, Warm Springs	*Cyprinodon nevadensis pectoralis*	Fish	Endangered
03/28/85	Spinedace, Big Spring	*Lepidomeda mollispinis praten*	Fish	Threatened
09/12/85	Spinedace, White River	*Lepidomeda albivallis*	Fish	Endangered
09/27/85	Springfish, Hiko White River	*Crenichthys baileyi grandis*	Fish	Endangered
03/31/86	Springfish, Railroad Valley	*Crenichthys nevadae*	Fish	Threatened
09/27/85	Springfish, White River	*Crenichthys baileyi baileyi*	Fish	Endangered
10/23/91	Sucker, Razorback	*Xyrauchen texanus*	Fish	Endangered
03/11/67	Topminnow, Gila	*Poeciliopsis occidentalis*	Fish	Endangered
10/13/70	Trout, Lahontan Cuttroat	*Oncorhynchus clarki henshawi*	Fish	Threatened
07/16/75	Trout, Paiute Cutthroat	*Oncorhynchus clarki seleniris*	Fish	Threatened
10/13/70	Woundfin	*Plagopterus argentissimus*	Fish	Endangered
05/20/85	Naucorid, Ash Meadows	*Ambrysus amargosus*	Insect	Threatened
09/30/88	Rat, Stephens' Kangaroo	*Dipodomys stephensi*	Mammal	Endangered
11/15/84	Vole, Amargosa	*Microtus californicus scirpensis*	Mammal	Endangered
10/01/87	Vole, Hualapai Mexican	*Microtus mexicanus hualpaiensis*	Mammal	Endangered
11/06/79	Bear-poppy, Dwarf	*Arctomecon humilis*	Plant	Endangered
05/20/85	Blazing Star, Ash Meadows	*Mentzelia leucophylla*	Plant	Threatened
10/26/79	Cactus, Siler Pincushion	*Pediocactus sileri*	Plant	Endangered
05/20/85	Centaury, Spring-loving	*Centaurium namophilum*	Plant	Threatened
08/31/84	Checker-mallow, Pedate	*Sidalcea pedata*	Plant	Endangered
05/29/84	Cliffrose, Arizona	*Purshia subintegra*	Plant	Endangered
05/05/86	Cycladenia, Jones	*Cycladenia humilis* var. *jonesii*	Plant	Threatened
04/26/78	Dune Grass, Eureka	*Swallenia alexandrae*	Plant	Endangered
04/26/78	Evening-primrose, Eureka Valley	*Oenothera avita* ssp. *eurekensis*	Plant	Endangered
05/20/85	Gumplant, Ash Meadows	*Grindelia fraxinopratensis*	Plant	Threatened
05/20/85	Ivesia, Ash Meadows	*Ivesia kingii* var. *eremica*	Plant	Threatened
05/20/85	Milk-vetch, Ash Meadows	*Astragalus phoenix*	Plant	Threatened
08/31/84	Mustard, Slender-petaled	*Thelypodium stenopetalum*	Plant	Endangered
05/20/85	Niterwort, Amargosa	*Nitrophila mohavensis*	Plant	Endangered
09/28/87	Spineflower, Slender-horned	*Dodecahema leptoceras*	Plant	Endangered
05/20/85	Sunray, Ash Meadows	*Enceliopsis nudicaulis* var. *corrugata*	Plant	Threatened

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List date	Common name	Scientific name	Taxon	Status
09/28/87	Woolly-star, Santa Ana River	*Eriastrum densifolium* ssp. *sanctorum*	Plant	Endangered
09/25/80	Lizard, Coachella Valley Fringe-toed	*Uma inornata*	Reptile	Threatened
04/02/90	Tortoise, Desert	*Gopherus agassizii*	Reptile	Threatened
Central/Southern California				
03/11/67	Salamander, Santa Cruz Long-toed	*Ambystoma macrodactylum croceum*	Amphibian	Endangered
03/11/67	Condor, California	*Gymnogyps californianus*	Bird	Endangered
02/14/78	Eagle, Bald	*Haliaeetus leucocephalus*	Bird	Endangered, Threatened
10/13/70	Falcon, American Peregrine	*Falco peregrinus anatum*	Bird	Endangered
03/11/67	Goose, Aleutian Canada	*Branta canadensis leucopareia*	Bird	Endangered
10/13/70	Pelican, Brown	*Pelecanus occidentalis*	Bird	Endangered
10/13/70	Rail, California Clapper	*Rallus longirostris obsoletus*	Bird	Endangered
10/13/70	Rail, Light-footed Clapper	*Rallus longirostris levipes*	Bird	Endangered
08/11/77	Shrike, San Clemente Loggerhead	*Lanius ludovicianus mearnsi*	Bird	Endangered
08/11/77	Sparrow, San Clemente Sage	*Amphispiza belli clementeae*	Bird	Threatened
10/13/70	Tern, California Least	*Sterna antillarum browni*	Bird	Endangered
05/02/86	Vireo, Least Bell's	*Vireo bellii pusillus*	Bird	Endangered
10/13/70	Chub, Mohave Tui	*Gila bicolor mohavensis*	Fish	Endangered
03/31/86	Pupfish, Desert	*Cyprinodon macularius*	Fish	Endangered
10/13/70	Stickleback, Unarmored Threespine	*Gasterosteus aculeatus williamsoni*	Fish	Endangered
10/13/70	Trout, Lahontan Cuttroat	*Oncorhynchus clarki henshawi*	Fish	Threatened
04/13/78	Trout, Little Kern Golden	*Oncorhynchus aguabonita whitei*	Fish	Threatened
07/16/75	Trout, Paiute Cutthroat	*Oncorhynchus clarki seleniris*	Fish	Threatened
08/08/80	Beetle, Valley Elderberry Longhorn	*Desmocerus californicus dimorphus*	Insect	Threatened
09/18/87	Butterfly, Bay Checkerspot	*Euphydryas editha bayensis*	Insect	Threatened
06/01/76	Butterfly, El Segundo Blue	*Euphilotes battoides allyni*	Insect	Endangered
07/01/76	Butterfly, Smith's Blue	*Euphilotes enoptes smithi*	Insect	Endangered
06/01/76	Moth, Kern Primrose Sphinx	*Euproserpinus euterpe*	Insect	Threatened
03/11/67	Fox, San Joaquin Kit	*Vulpes macrotis mutica*	Mammal	Endangered
10/13/70	Mouse, Salt Marsh Harvest	*Reithrodontomys raviventris*	Mammal	Endangered
01/14/77	Otter, Southern Sea	*Enhydra lutris nereis*	Mammal	Threatened
01/30/85	Rat, Fresno Kangaroo	*Dipodomys nitratoides exilis*	Mammal	Endangered
01/05/87	Rat, Giant Kangaroo	*Dipodomys ingens*	Mammal	Endangered
10/13/70	Rat, Morro Bay Kangaroo	*Dipodomys heermanni morroensis*	Mammal	Endangered
09/30/88	Rat, Stephens' Kangaroo	*Dipodomys stephensi*	Mammal	Endangered
07/08/88	Rat, Tipton Kangaroo	*Dipodomys nitratoides*	Mammal	Endangered
09/28/78	Bird's-beak, Salt Marsh	*Cordylanthus maritimus* ssp. *maritimus*	Plant	Endangered
07/01/86	Bird's-beak, Palmate-bracted	*Cordylanthus palmatus*	Plant	Endangered

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List date	Common name	Scientific name	Taxon	Status
08/11/77	Broom, San Clemente Island	*Lotus dendroideus* ssp. *traskiae*	Plant	Endangered
08/11/77	Bush-mallow, San Clemente Island	*Malacothamnus clementinus*	Plant	Endangered
07/19/90	Cactus, Bakersfield	*Opuntia treleasei*	Plant	Endangered
02/12/85	Evening-primrose, San Benito	*Camissonia benitensis*	Plant	Threatened
08/11/77	Indian Paintbrush, San Clemente Island	*Castilleja grisea*	Plant	Endangered
07/19/90	Jewelflower, California	*Caulanthus californicus*	Plant	Endangered
08/11/77	Larkspur, San Clemente Island	*Delphinium kinkiense*	Plant	Endangered
04/26/78	Liveforever, Santa Barbara Island	*Dudleya traskiae*	Plant	Endangered
07/19/90	Mallow, Kern	*Eremalche kernensis*	Plant	Endangered
09/28/78	Mesa Mint, San Diego	*Pogogyne abramsii*	Plant	Endangered
07/19/90	Woolly-star, Hoover's	*Eriastrum hooveri*	Plant	Threatened
07/19/90	Wooly-threads, San Joaquin	*Lembertia congdonii*	Plant	Endangered
03/11/67	Lizard, Blunt-nosed Leopard	*Gambelia silus*	Reptile	Endangered
08/11/77	Lizard, Island Night	*Xantusia riversiana*	Reptile	Threatened
04/02/90	Tortoise, Desert	*Gopherus agassizii*	Reptile	Threatened
10/13/70	Turtle, Green Sea	*Chelonia mydas*	Reptile	Endangered, Threatened

Northern California

02/14/78	Eagle, Bald	*Haliaeetus leucocephalus*	Bird	Endangered, Threatened
10/13/70	Falcon, American Peregrine	*Falco peregrinus anatum*	Bird	Endangered
03/11/67	Goose, Aleutian Canada	*Branta canadensis leucopareia*	Bird	Endangered
06/26/90	Owl, Northern Spotted	*Strix occidentalis caurina*	Bird	Endangered
10/13/70	Pelican, Brown	*Pelecanus occidentalis*	Bird	Endangered
10/13/70	Rail, California Clapper	*Rallus longirostris obsoletus*	Bird	Endangered
10/13/70	Tern, California Least	*Sterna antillarum browni*	Bird	Endangered
10/31/88	Shrimp, California Freshwater	*Synacaris pacifica*	Crustacean	Endangered
04/22/92	Salmon, Sacramento Winter Chinook	*Oncorhynchus tshawytscha*	Fish	Threatened
08/03/80	Beetle, Delta Green Ground	*Elaphrus viridis*	Insect	Threatened
08/08/80	Beetle, Valley Elderberry Longhorn	*Desmocerus californicus dimorphus*	Insect	Threatened
09/18/87	Butterfly, Bay Checkerspot	*Euphydryas editha bayensis*	Insect	Threatened
06/01/76	Butterfly, Lange's Metalmark	*Apodemia mormo langei*	Insect	Endangered
06/01/76	Butterfly, Lotis Blue	*Lycaeides argyrognomon lotis*	Insect	Endangered
06/01/76	Butterfly, Mission Blue	*Icaricia icarioides missionensis*	Insect	Endangered
06/01/76	Butterfly, San Bruno Elfin	*Callophrys mossii bayensis*	Insect	Endangered
03/11/67	Fox, San Joaquin Kit	*Vulpes macrotis mutica*	Mammal	Endangered
12/12/91	Mountain Beaver, Point Arena	*Aplodontia rufa nigra*	Mammal	Endangered
10/13/70	Mouse, Salt Marsh Harvest	*Reithrodontomys raviventris*	Mammal	Endangered
07/01/86	Bird's-beak, Palmate-bracted	*Cordylanthus palmatus*	Plant	Endangered

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List date	Common name	Scientific name	Taxon	Status
01/08/87	Cypress, Santa Cruz	*Cupressus abramsiana*	Plant	Endangered
04/26/78	Evening-primrose, Antioch Dunes	*Oenothera deltoides* ssp. *howellii*	Plant	Endangered
12/02/91	Goldfields, Burke's	*Lasthenia burkei*	Plant	Endangered
09/28/78	Grass, Solano	*Tuctoria mucronata*	Plant	Endangered
10/26/79	Manzanita, Presidio	*Arctostaphylos pungens* var. *ravenii*	Plant	Endangered
12/02/91	Meadowfoam, Sebastopol	*Limnathes vinculans*	Plant	Endangered
09/28/78	Rock-cress, McDonald's	*Arabis mcdonaldiana*	Plant	Endangered
12/02/91	Stickyseed, Baker's	*Blennosperma bakeri*	Plant	Endangered
08/01/85	Thistle, Loch Lomond Coyote	*Eryngium constancei*	Plant	Endangered
09/18/90	Thornmint, San Mateo	*Acanthomintha obovata* ssp. *duttonii*	Plant	Endangered
04/26/78	Wallflower, Contra Costa	*Erysimum capitatum* var. *angustatum*	Plant	Endangered
03/11/67	Snake, San Francisco Garter	*Thamnophis sirtalis tetrataenia*	Reptile	Endangered

Abstract

Flather, Curtis H.; Joyce, Linda A.; Bloomgarden, Carol A. 1994. Species endangerment patterns in the United States. Gen. Tech. Rep. RM-241. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 42 p.

The single-species approach to conserving threatened and endangered species in the United States is insufficient, given the number of species (more than 700) officially considered at risk of extinction (i.e., formally listed under the Endangered Species Act of 1973), the rate at which new species are being listed (more than 50 species a year), and the number of species awaiting listing (more than 3,500 candidate species). Regions supporting many endangered species were located in the humid Southeast and the arid Southwest, and tended to be unique with respect to taxonomic composition, prevalence of endemism, climate, land-type associations, and factors contributing to species endangerment. A comparison of the state-level distribution of candidate, Category 1 species indicated that general spatial patterns would remain consistent with the present distribution of endangerment regions; only the Pacific Northwest emerged as a new concentration of endangered species. Directing land management and policy considerations to endangerment regions could increase the efficiency (e.g., multiple species benefits) of efforts to conserve endangered species.

Keywords: Threatened and endangered species, species rarity, spatial distribution, regions of species endangerment

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